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May 24, 2006

VIA HAND DELIVERY

Ms. Victoria Rutson
Chief
Section of Environmental Analysis
Surface Transportation Board
1925 K Street, N.W.
Washington, D.C. 20423

Re: **Tongue River Railroad Company, Inc. - Finance Docket 31086 (Sub-No. 3) - Construction and Operation of the Western Alignment**

Dear Ms. Rutson:

As you know, Tongue River Railroad Company, Inc. ("TRRC") and the Montana Department of Fish, Wildlife & Parks ("Department") have reached agreement on an April 13, 2006 "Revised Work Plan for High Resolution Vibration Monitoring, Evaluation of Potential Effects of Tongue River Railroad Construction and Operation, and Potential Mitigation at Miles City Fish Hatchery" ("Fish Hatchery Monitoring Program"). A copy of that Monitoring Program is attached. The Department has advised TRRC that it concurs with the Monitoring Program and has authorized TRRC to enter Miles City Fish Hatchery ("Hatchery") property to perform baseline monitoring contemplated by the Monitoring Program. That monitoring has in fact already begun. The Monitoring Plan also contemplates further studies if it is concluded on the basis of initial monitoring that construction and operation of the TRRC line will result in higher vibration and noise levels than currently exist at critical facilities at the Hatchery.

TRRC hereby requests that the attached Monitoring Plan be incorporated into the Final Supplemental EIS as a voluntary mitigation measure. Further, TRRC is not aware of any issues raised by the Department in this proceeding relating to the Department's concerns about the impact of the TRRC line on the Hatchery that have not now been fully resolved and, where appropriate, addressed in mitigation measures incorporated in the Draft SEIS. TRRC notes, however, that the Department has advised TRRC that it prefers that draft Mitigation Measure No. 86 (MCFH Continuing Consultation), concerning time frames and a process for addressing any issues of concern to the Department, be

retained in the Final SEIS. TRRC does not object to the retention of that mitigation measure in the Final SEIS.

Please let me know if you have any questions.

Sincerely,

David H. Coburn
Attorney for Tongue River Railroad Company, Inc.

cc: Mr. Ken Blodgett
Mr. Scott Steinwert
Ms. Mary Bean
Mr. Douglas Day
Mr. Jeff Hagener
Mr. Rodney Schwartz

Womack & Associates, Inc.
Geology and Geotechnical Engineering

April 13, 2006

Doug Day
Tongue River Railroad Company
P.O. Box 1181
Billings, MT 59103-1181

RE: REVISED WORK PLAN FOR HIGH RESOLUTION VIBRATION MONITORING, EVALUATION OF POTENTIAL EFFECTS OF TONGUE RIVER RAILROAD CONSTRUCTION AND OPERATION, AND POTENTIAL MITIGATION AT MILES CITY FISH HATCHERY

Dear Doug:

I have attached a revised work plan for evaluation of potential effects of vibrations and noise from TRR construction and operation at the Miles City Fish Hatchery (MCFH). Existing very low level vibrations will be measured at the hatchery by Wilson Ihrig Associates (WI) using high resolution equipment. Propagation of vibrations from TRR will be predicted by WI from in situ acoustic data. The vibration data will be evaluated by WI and Shannon & Wilson, Inc. (SW), to determine whether there may be potential effects to hatchery operation. If the hatchery is likely to be affected, acceptability criteria will be determined in cooperation with research personnel from the US Fish and Wildlife Service.

Respectfully submitted,

Womack & Associates, Inc.,

Ray Womack, P.E., P.G.

5602 Hesper Road, Billings Montana 59106 (406) 656-5398

TONGUE RIVER RAILROAD

April 13, 2006

Mr. Jeff Hagener
Director
Montana Department of Fish, Wildlife & Parks
1420 East 6th Avenue
Helena, MT 59601

Re: Tongue River Railroad – Miles City Fish Hatchery Revised Monitoring Plan

Dear Mr. Hagener:

As you may know, we have been working with your agency and the U.S. Fish Wildlife Service to develop a plan for monitoring baseline noise and vibration levels at the Miles City Fish Hatchery, as well as the impacts, if any, that might result from the construction and operation of the Tongue River Railroad.

As a result of a meeting held April 6, 2006 between representatives of Montana Fish, Wildlife & Parks, the U.S. Fish Wildlife Service, and representatives of the Tongue River Railroad Company, our consultant, Womack and Associates, Inc., teamed with Shannon & Wilson, Inc. and Wilson, Ihrig & Associates, Inc., have prepared the attached revised "Miles City Fish Hatchery Acoustical Study" plan. The team has prepared the plan based on the results of the April 6th meeting at the Bozeman Fish Technology Center.

We believe the plan meets the criteria established at the April 6th meeting. In order to complete the process of having an agreed to monitoring plan in place as soon as possible, we will call you early next week to discuss the plan and the timing of your response to it. Should you have any questions in the interim, please do not hesitate to call.

Sincerely,

Pat Davison

cc: Chris Hunter (w/enclosure)
Bob Snyder (w/enclosure)
Debby Dils (w/enclosure)
Mark Wilson (w/enclosure)
Molly Webb (w/enclosure)
Yvette Converse (w/enclosure
Lou Hanebury (w/enclosure)
Mike Volesky (w/enclosure)
Ken Blodgett (w/enclosure)
Vicky Rutson (w/enclosure)

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Womack & Associates, Inc.
Geology and Geotechnical Engineering

MILES CITY STATE WARM-WATER FISH HATCHERY

REVISED WORK PLAN FOR HIGH RESOLUTION VIBRATION MONITORING, EVALUTION OF POTENTIAL EFFECTS OF TONGUE RIVER RAILROAD CONSTRUCTION AND OPERATION, AND POTENTIAL MITIGATION AT MILES CITY FISH HATCHERY

Prepared by:
Womack & Associates, Inc.,
Wilson, Ihrig & Associates, Inc.
Shannon & Wilson, Inc.

April 13, 2006

MILES CITY FISH HATCHERY ACOUSTICAL STUDY

The potential impacts of the Tongue River Railroad (TRR) on the Miles City Fish Hatchery (MCFH) have been studied extensively. Vibration levels have been measured along the existing BNSF rail and at the hatchery. Potential effects on fish of vibrations, windblown coal dust, and weed control have been assessed by experts. Geological conditions have been thoroughly researched and slope stability concerns have been addressed. However, in response to an issue raised by the Montana Department of Fish, Wildlife, and Parks, the work plan described herein has been developed. The work plan represents a refinement of the previous work specifically targeting very low level acoustics and vibration.

The noise and vibration program will include measurements and analysis to:

- Measure baseline conditions at the MCFH
- Predict and assess future sound pressure levels from construction and operation of the TRR near the MCFH and compare to baseline conditions.
- Measure actual noise and vibration during the construction and operation of the TRR to compare actual levels to predicted levels.
- If the predicted or measured levels of noise and vibration show an increase over baseline conditions, then determine acceptability criteria for increased noise and vibration associated with the TRR line in association with the US Fish and Wildlife Service (USFWS) and the Montana Fish, Wildlife & Parks (MTFWP).
- If necessary, recommend mitigation measures to be incorporated into the engineering design phase of TRR rail construction.

This study will focus primarily on the MCFH Headquarters building, although potential effects to other structures in which fish are located will be considered. Access to the hatchery facility will be coordinated with MTFWP. Womack & Associates (WA) will coordinate the work, provide geological and geotechnical consulting, and report to Tongue River Railroad Company (TRR). WA has teamed with Wilson Ihrig and Shannon & Wilson on the design of the monitoring study. Wilson Ihrig (WI) will conduct the noise and vibration work, Shannon & Wilson (SW) will assess effects to fish and appropriate action levels, and the team will evaluate mitigation measures. The work will be performed in cooperation with the US Fish and Wildlife Service (USFWS).

This team brings extraordinary qualifications and experience to the project. Detailed qualifications and resumes are appended and are summarized below.

Wilson, Ihrig & Associates, Inc. is a world renowned consulting firm that provides a complete range of professional services associated with acoustics and the assessment and control of noise and vibration. WI specializes in transit system and railroad noise and vibration control and

draws from 40 years of experience with modern rail systems. WI projects include the DM&E Powder River Basin expansion, Bay Area Rapid Transit (BART), the Puget Sound Light Rail system, the Superconducting Supercollider, and research on construction vibration for the US Department of Transportation. WI wrote the Handbook of Urban Rail Noise and Vibration Control under contract to US DOT. Dr. James Nelson and Dr. George Wilson, who will provide senior review, each are graduates of the University of California at Berkeley, and have more than 30 years experience. Derek Watry, WI's lead consultant for the project, has a M.S. from UC Berkeley and 13 years experience with WI.

Shannon & Wilson has provided engineering and environmental consulting on more than 20,000 projects worldwide in the past 50 years. SW's natural resources services include regulatory compliance, wetlands, plant and animal surveys, fisheries, habitat remediation, water quality, biological assessments, and evaluation of impacts to threatened and endangered species. Murray Meierhoff, principal in SW's St. Louis office, has a M.A in Aquatic Biology from the University of Missouri and 20 years experience in aquatic biology, ecology, and limnology. He has worked extensively with the warm water fisheries of Illinois, Missouri, Pennsylvania, Kansas, and Mississippi.

Womack & Associates has provided geotechnical and geological consulting services in Montana since 1978. Ray Womack, P.E., P.G., has a M.S. in Earth Resources from Colorado State University and more than 30 years experience in the western US, as well as sub-Saharan Africa, Asia, and Central America. Mr. Womack assembled and led the geotechnical team for the TRR project beginning in 1997 and has been responsible for assessment of site conditions and vibration monitoring at the Miles City Hatchery since 1998.

SCOPE OF WORK

1.0 MEASURE BASELINE LEVELS

The existing ambient noise and vibration levels at the MCFH in Miles City, Montana, will be measured. Sources of existing noise and vibration at Miles City include pumps and other mechanical equipment in the Hatchery Headquarters, existing rail operations on the BNSF line (which are expected to be reduced once the TRR line becomes operational), and highway traffic on Interstate-94. Using these measurements, the environmental conditions which are currently prevalent at the hatchery will be established. USFWS and MTFWP will be consulted regarding the design of the study.

High-sensitivity, low noise floor transducers, low noise floor amplifiers, and digital-audio signal recorders will be used to quantify both noise and/or vibration over a frequency range of 1 Hz to 10,000 Hz. The transducers will include a hydrophone (for underwater measurements), seismic accelerometers, and precision microphones. All signal data will be recorded for later laboratory

data analysis. Special, large diameter wind screens will be used to reduce wind-generated noise interference for outdoor noise measurements, if necessary.

It is anticipated that the data will be resolved into standardized 1/3-octave band levels. If issues arise regarding specific frequencies, additional data analyses could include narrowband resolution of the data.

2.0 PREDICT FUTURE NOISE AND VIBRATION LEVELS

2.1 Construction Operations

Construction activities are likely to include, but not necessarily be limited to, excavation, compaction, and bulldozing. Of these, compaction typically generates the most vibration and noise. Transfer functions between the construction site and sensitive facilities at the MCFH will be predicted from results of in situ testing, probably using a heavy vibrating roller as the energy source. Continuous vibration monitoring will be performed during critical construction periods.

2.2 Rail Operations

To predict future vibration and underwater sound pressure levels from rail operations, the methodology first developed by the staff of WI in the 1970s, now adopted as the industry standard, will be employed. Briefly, the methodology breaks train vibration into two pieces: the dynamic forces inherently generated by the train at the wheel/rail interface and the transmission of those dynamic forces as ground vibration. The former is the train *force density level* (FDL) and the latter the ground *line source response* (LSR). The FDL of the existing BNSF trains at one location near the MCFH will be measured, and the LSR from the proposed right-of-way into the hatchery will be measured at two or three locations. These data, along with any minor adjustments necessary to correct for anticipated speed or other differences, will be used to predict future vibration in the hatchery. The methodology produces results in the 6.3 Hz to 160 Hz 1/3-octave bands which encompasses all significant railroad vibration frequencies. The predicted vibration will be used to predict underwater acoustic levels inside the hatchery tanks.

To predict future noise from railroad operations, recorded noise levels from existing BNSF trains and reasonable estimates of the sound transmission loss afforded by the MCFH Headquarters building will be used after its construction and condition have been examined.

2.3 Measurement Equipment and Data Analysis

The FDL and LSR testing will use specialized equipment designed by and built by or for WI, in addition to commercially purchased geophones and data recorders. Noise and vibration from construction activities will use the same equipment used to measure the existing conditions. Data will be resolved on a 1/3-octave band basis for direct comparison with the established action levels.

2.4 Assessment

. The work plan assumes that assessment of predicted noise and vibration levels will involve comparison with existing levels. If the future vibration and noise are expected to exceed existing levels, the team will develop a research plan in cooperation with USFWS and MTFWP. Wilson Ihrig will be responsible for measurement of baseline levels and prediction of future levels. Shannon & Wilson and USFWS will be responsible for evaluation of appropriate acceptability criteria based on potential impacts to fish.

3.0 DEFINE ACCEPTABILITY CRITERIA

At a meeting between representatives of MTFWP, USFWS, and representatives of TRR held April 5, 2006, it was agreed that existing noise and vibration levels would be measured at the MCFH and compared to levels predicted during construction and operation of the rail. Although it is clear that fish hatcheries have been in successful operation for decades in locations with perceptible levels of both noise and vibration, actual effects of noise and vibration on fish are not completely understood. If it is concluded that construction and operation of the rail are likely to cause higher noise and vibration levels than currently exist in critical facilities at the MCFH, potential impacts and mitigation measures will be assessed. Specifically, bioassays will be performed that evaluate stress response due to increased vibration and noise by measuring levels of substances that indicate stress response in blood samples of shovelnose sturgeon (as a proxy for pallids) at various stages of development. The study will be performed by USFWS, with assistance from WI and SW, at the Fish Technology Center in Bozeman, or at other sites determined by the team. Dr. Molly Webb, research biologist for USFWS, has prepared a preliminary research proposal (attached in Appendix 2) and will work with WI and SW to develop testing protocols, if noise and vibration are expected to increase because of the TRR. Bob Snyder and Mike Rhodes of MTFWP will also be involved in preparation of the testing program.

SW will evaluate, in both natural settings and at the MCFH, potential stressors to pallid sturgeon and other species. Other species include walleye, sauger, largemouth bass, smallmouth bass, northern pike, and tiger muskellunge. Ecological characteristics of these fish, in terms of feeding preferences, habitat preferences, growth rates, predators, and distribution will be documented. The majority of this work will be completed from information gathered from technical literature or interviews. In addition, Murray Meierhoff of SW, an aquatic biologist, will visit the MCFH to observe conditions, interact with other team members, and develop information regarding the soils and geology in the vicinity of the proposed rail line. This task will include a review of vibration and noise data from published sources and/or developed by others.

4.0 COMPARE BASELINE AND PREDICTED LEVELS WITH ACCEPTABILITY CRITERIA THRESHOLDS

Based on the baseline, predicted levels, and acceptability criteria, the team will determine whether mitigation measures should be considered during the final engineering design phase. The work plan assumes that assessment of predicted noise and vibration levels will involve comparison with the acceptability criteria established under Task 3.0. If the future vibration and noise levels are expected to exceed acceptability criteria, the team will develop mitigation procedures.

5.0 DEVELOP MITIGATION MEASURES (IF NECESSARY)

If required by the assessment conducted above, the team will develop remedial measures to be incorporated in the final design engineering phase that maintain vibration levels at the MCFH at or below no-impact levels. This work will utilize the team's knowledge of railroad and construction operations in general, site-specific information on the geology of the area, ecological information regarding the pallid sturgeon and other species reared at MCFH, and vibration/noise data.

WI has been designing systems to reduce rail vibration since the 1970s, and is confident that successful mitigation measures can be designed for this application, if necessary. SW is also highly experienced in design and implementation of mitigation measures. Potential mitigation measures at the rail include resilient rail fasteners and rubber ballast mats, among others. At the hatchery, tanks may be isolated from vibration. Noise, if found to be an issue, could be mitigated by modifying the MCFH Headquarters building to increase the shell sound transmission loss. This can be done, if necessary, while retaining airflow through the building.

6.0 MONITOR NOISE AND VIBRATION FROM CONSTRUCTION AND INITIAL RAIL OPERATIONS

Once the previous tasks have been completed, the team will have a better understanding of the existing noise and vibration environment and expected future levels as a function of distance from the TRR right-of-way. At that point, the team will be able to design a responsible monitoring program to verify the predicted levels and/or monitor any mitigation measures that may have been implemented as a result of the efforts described above.

For planning purposes it is assumed the team will follow WI's normal procedure for monitoring vibration at critical sites, which consists of live (attended) monitoring and continuous unattended monitoring. The live monitoring would occur for the first few days of any new major construction activity (e.g., grading, compacting) and operations. WI will use the same high-sensitivity instruments used during the engineering site-work and, prior to construction, the team will have established a protocol with the contractor or operator to cease operations if the levels exceed the action levels. For long-term construction activities, after the first few days, monitoring would be done using portable seismographs that will be strategically placed based on the results of the vibration study. These seismographs can be used to trigger an alarm to alert the construction crew if action levels are exceeded, and can also be programmed to call up to four people with alerts.

7.0 REPORT

All measurements, analysis, findings, and conclusions generated by Womack & Associates, Wilson Ihrig, and Shannon & Wilson will be presented in a single technical report.

8.0 PERSONNEL

Qualifications and resumes of individuals involved in the project from Womack & Associates, Wilson Ihrig & Associates, and Shannon & Wilson are attached in Appendix 1.

APPENDIX 1
STATEMENTS OF QUALIFICATIONS AND RESUMES OF KEY PERSONNEL

WOMACK & ASSOCIATES, INC. STATEMENT OF QUALIFICATIONS

1.0 BACKGROUND AND EXPERIENCE

Ray Womack established a consulting practice in Billings in 1982 which grew into Womack & Associates, Inc. (WAI). The firm now has offices in Billings and Bozeman, and specializes in geotechnical engineering, engineering geology, and geomorphology. We work in a large geographical area, routinely performing projects throughout the western United States and abroad. Our work has consisted of a mix of commercial, residential, and industrial projects. We have provided geotechnical consulting services for many hotels, schools, roads, and high-end residences. Our industrial experience has been gained from work on large mine structures and cleanups at contaminated industrial sites, including many CERCLA (Superfund) projects. We have particular expertise in evaluation of slope stability and seismicity.

At present the staff consists of two geotechnical engineers and a drafter. Although we are a small firm, we have been involved in many large, complex projects, and we believe our background and experience prepare us very well to address the problems that occur at complex sites. Resumes for our professional staff are available upon request, and brief discussions of their experience follow.

Ray Womack, P.E., P.G., President and Principal Engineer, has 30 years experience as a geotechnical engineer and geoscientist. Mr. Womack holds degrees from Virginia Polytechnic Institute (BS-geophysics and geology) and Colorado State University (MS-geology). He is registered as a Professional Engineer in six states and as a Professional Geologist. He is a member of the Association of Engineering Geologists and the American Society of Civil Engineers. Mr. Womack has written many papers and presented technical courses dealing with landslides, risk assessment, and river mechanics.

Mr. Womack has conducted foundation investigations, stability analyses, and geologic hazards evaluations in 17 states, including most of the Rocky Mountain states. He has worked extensively in southern and eastern Africa, as well as Guatemala, Haiti, Kazakhstan and the Republic of Georgia. He has prepared foundation reports for hundreds of structures, including mine facilities, railroads, power plants, hotels, schools, and roads. He has been responsible for investigation of many landslides and other difficult sites. He has led geotechnical efforts at numerous environmental projects, including Asarco CERCLA projects in Tacoma, Washington; East Helena, Montana; Murray, Utah, and elsewhere.

David Cameron, P.E., has 21 years professional experience, including 14 years as a geotechnical engineer. He is a graduate of the University of Colorado at Denver (B.S., Civil

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Engineering). Mr. Cameron works under contract to WAI in Bozeman. He has been responsible for slope stability issues along the proposed 119-mile Tongue River Railroad and the Central Montana Railway. He prepared cover and liner designs for the hazwaste landfill at the Asarco Tacoma Smelter. Major mining projects have included the Cyprus Miami and Magma Pinto Valley copper projects in Arizona, the Chino and Ortiz projects in New Mexico, the Bullfrog Mine in Nevada, Grouse Creek and Black Pine mines in Idaho, Rock Creek and Zortman in Montana, and Freeport Indonesia in Irian Jaya.

2.0 GEOTECHNICAL ENGINEERING

WAI provides site investigation and design services for earthworks, dams, roads, railways, and other structures. Many of our projects have involved landslides and other slope stability problems. Monitoring instruments, including extensometers, tiltmeters, and slope indicators have frequently been installed. In seismically active areas, we have analyzed seismicity and liquefaction potential for sensitive structures. A short list of selected projects follows:

- Tongue River Railroad geotechnical investigation and design
- Beartooth Highway Emergency Repair
- BNSF Yellowstone River slope stability mitigation
- Central Montana Railway landslide mitigation
- Asarco Ray copper electrowinning facility settlement, Arizona
- Asarco Mission tailings impoundments, Arizona
- Asarco lead battery recycling plant, North Carolina
- Hazwaste landfill, roads, landslide mitigation, seismicity, Tacoma Smelter
- PPL Montana impoundments, Colstrip
- Bearpaw Reservoir, Montana DNRC
- BLM dams, near Zortman
- Stillwater Mine East Boulder Access Road, near Big Timber
- Western Energy settlement investigations, Colstrip
- Dinosaur National Monument landslide, Colorado
- Buffalo Jump landslide
- Cathedral Mountain landslide litigation
- Big Sky landslides
- Schools at Malta, Glasgow, Drummond, and Billings
- Jackson and Wilson Schools, Wyoming
- Teton Science School, Jackson, Wyoming
- Beaver Creek and Gros Ventre housing facilities, Grand Teton National Park

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- JY and Moose Visitor Centers, Grand Teton National Park
- Four Seasons Resort, Teton Village, Wyoming
- Renaissance Hotel, Teton Village, Wyoming
- Teton Lodge, Teton Village, Wyoming
- Teton Club, Teton Village, Wyoming
- Red Lodge Mountain slope stability and lined water storage
- Navajo Reservation bridges, New Mexico and Arizona
- Moonlight Basin, Big Sky

3.0 ENVIRONMENTAL PROJECTS

WAI has provided geotechnical and geological services on major environmental cleanups, including CERCLA sites in several states. These sites are large industrial facilities with numerous problems and complex geotechnical requirements. Several of the projects have been ongoing for more than nine years. The Asarco Tacoma Smelter CERCLA site has been particularly challenging, involving geotechnical design of a hazardous waste landfill on a sensitive site adjacent to Puget Sound. The site is seismically active and subject to serious potential settlement, liquefaction, and slope stability problems. Our experience and background on environmental projects includes the following:

- Hazardous waste landfill design
- Seismic and liquefaction analysis
- Slope stability
- Foundation design
- Geosynthetic covers and liners
- Site investigations

WAI has worked on the following environmental projects:

- Asarco Tacoma Smelter CERCLA site, Washington
- Asarco Murray Smelter CERCLA site, Utah
- Asarco East Helena Smelter CERCLA site
- Asarco Omaha Smelter CERCLA site, Nebraska
- Asarco Yak Tunnel CERCLA site, Leadville, Colorado
- Asarco Beckemeyer CERCLA site, Illinois
- Asarco Henrietta CERCLA site, Oklahoma
- Pacific Recycling CECRA sites, Billings
- Asarco lead battery recycling plant, North Carolina

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- Major refinery gasoline plume interception, Billings
- Pennsylvania Power and Light (PPL) interception drains, Colstrip, Montana
- PPL fly ash and process water impoundments, Colstrip
- Rosebud Power fly ash pond, Colstrip
- Columbia Falls aluminum landfill cover
- Getter Trucking facilities, Wyoming, North Dakota, Montana
- Lander and Winkleman Dome oil fields, Wyoming
- Hardscrabble oil field, North Dakota
- Four Eyes oil field, Montana
- Brush Lake oil field, Montana
- Injection wells, North Dakota and Montana

4.0 ACTIVE MINES

Ray Womack has worked on coal and hardrock projects in Montana since 1978. WAI has been involved in design, operation, and closure of many major projects in Montana and the western U.S. Our background includes the following areas of work:

- Slope stability--heap leach pads, waste repositories, landslides
- Reclamation--covers, liners, water treatment facilities
- Dams
- Major diversions
- Foundations for surface facilities

4.1 HARDROCK MINES

Hardrock mining projects include the following:

- Pegasus Zortman
- Stillwater platinum
- Asarco Rock Creek
- Noranda Crown Butte
- Phelps Dodge/Canyon Resources MacDonald and Sevenup Pete
- CR Kendall
- Basin Creek
- Hecla Grouse Creek, Idaho
- Stibnite, Idaho
- Echo Bay Republic, Washington

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- CR Briggs, California
- Sonora Mining, California
- Asarco Ray and Mission, Arizona
- Asarco Coy, New Market, and Young zinc mines, Tennessee
- Cambior Carlota, Arizona
- Bolnisi heap leach, Republic of Georgia
- Jezkazgan copper leach, Kazakhstan

4.2 COAL MINES

Coal projects include the following:

- Westmoreland Absaloka
- Montco
- Bull Mountains (Louisiana Land and Exploration)
- Wesco Cook Mountain
- Consolidation Coal Otter Creek
- Meridian Cook Creek
- Meridian Circle West
- Ft. Union, Wyoming
- Consolidation Coal Ash Creek, Wyoming

5.0 GEOMORPHOLOGY

WAI has performed stream channel investigations and remediation projects for mines, conservation districts, and landowners. Ray Womack has published technical papers and has served as an expert witness and consultant in litigations involving boundary disputes and erosion problems along rivers. His work on stream channel erosion has been cited in a number of textbooks. The company has recently prepared cumulative impact assessments for channel training projects along the Yellowstone River near Billings, the first study of its type to be performed in this region. We are currently doing similar assessments for proposed channel training projects along the BNSF railroad Yellowstone River corridor between Billings and the North Dakota line. Specific projects include the following:

- Yellowstone cumulative impact study, Yellowstone Co.
- BNSF Yellowstone cumulative impact study
- Clark Fork litigation, Missoula
- Yellowstone litigation, Sidney

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- Missouri River litigation, Culbertson
- Sun River litigation, Cascade County
- Careless Creek erosion, Musselshell County
- Two Medicine Canal blowout, Blackfoot Reservation
- Alder and McGinnis Canal failures, Blackfoot Reservation
- Douglas Creek erosion, Colorado
- Carter Gulch debris flows and channel reclamation, Zortman
- Ruby Gulch channel reclamation, Zortman

6.0 CLIENT LIST

6.1 INDUSTRIAL CLIENTS

Asarco • BNSF • Cambior • Canyon Resources • Central Montana Railway • Consolidation Coal • Darling International • Echo Bay Minerals • Exxon Billings Refinery • Getter Trucking • Hecla Mines • Koch Materials • Montana Power Co. • Montco • Nance Petroleum • Noranda • Pacific Recycling • Pegasus Gold • Pennsylvania Power and Light (PPL Montana) • Phelps-Dodge • Stillwater PGM • The Industrial Company (TIC) • Tongue River Railroad • Western Energy • Westmoreland Resources • Zortman Mining Inc.

6.2 PUBLIC CLIENTS

Billings Public Utilities Department • City of Lander, Wyoming • Montana Dept. Environmental Quality • Montana Dept. Fish Wildlife and Parks • Montana Dept. Natural Resources and Conservation • Montana Dept. Transportation • Northern Cheyenne Housing Authority • U.S. Bureau of Indian Affairs • U.S. Department of Justice • U.S. Forest Service • U.S. National Park Service • U.S. Public Health Service • U.S. NRCS • Wyoming Dept. of Environmental Quality

6.3 PRIVATE CLIENTS

Briarwood Country Club • Dreyfus Property Group • Grand Targhee Ski Resort • Leon Hirsch • Jackson Hole Ski Corporation • Michael Keaton • Moonlight Basin Ranch • Red Lodge Mountain Ski Area • Snake River Associates • State Farm Insurance • Travelers Insurance

6.4 ENGINEERS AND ARCHITECTS

A&E Architects • CTA Architects Engineers • Carney Architects • Charney Architects • CDM • Engineering Inc. • Fluidyne • Jonathan Foote Architects • Golder Associates • Hydrometrics •

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Jacobsen Construction • Jorgensen Engineering • McLaughlin Architects • Miller Levine Architects • Morrison-Maierle • R.D. Nielson Architects • Rendezvous Engineering • SK Geotechnical • Schafer & Associates • Daniel Smith Architect • Thomas Dean & Hoskins • URS Corp.

6.5 ATTORNEYS

Brown et al • Corette et al • Crowley • Edwards • Felt Law Firm • Jardine • Landoe • Matovich & Keller • Molloy Law Firm • Moulton • Stacey and Walen

7.0 PUBLICATIONS AND PRESENTATIONS

Womack, W.R., 2006, Landslides triggered by hurricane Stan in western Guatemala, investigation and mitigation in a developing environment: 40th Annual Symposium on Engineering Geology and Geotechnical Engineering, Utah State University.

Mokwa, R., W.R. Womack, and D.P. Cameron, 2004, Quantifying the risk of construction in landslide prone areas: Proceedings for ASCE Geo-Trans Geotechnical Engineering for Transportation Projects, Special Publication No. 126, p. 2010-2019.

Womack, W.R., 2004, River changes and property boundary disputes: Montana Bar Association CLE, Miles City, Montana.

Womack, W.R., and D.P. Cameron, 2003, Risks and consequences of remobilization of ancient landslides: Short course presented at Geohazards Symposium, MSU Engineering Festival, Bozeman, Montana.

Womack, W.R., 2003, Permitting within a corridor management plan: Great Northern Environmental Stewardship Association Meeting, Kalispell, Montana.

Womack, W.R., and K. Boyd, 2002, Alteration of Yellowstone River form and habitat over the past 50 years: Yellowstone River Floodplain Workshop, Billings, Montana.

Womack, W.R., 2002, Water storage in the coal fields of the Northern Plains; lessons from failures: Montana: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., and K. Boyd, 2001, Stream channel restoration and the illusion of function: Montana Mine Design, Operations, and Closure Conference, Whitefish, Montana.

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Womack, W.R., 2001, Response and recovery of the Missouri River downstream of Ft. Peck Dam, with resulting property boundary disputes *in* Applying Geomorphology to Environmental Management: Water Resources Publications, Ft. Collins, Colorado, p. 429-456.

Womack, W.R., and R. Perkins, 2000, Effects of management on river form and habitat in Yellowstone County: Assn. Montana Floodplain Managers Conference, Butte.

Womack, W.R., 1999, Yellowstone River geomorphology: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., F.R. Greguras, G.S. Vick, D.K. Nation, and T. Aldritch, 1998, Hidden hazard: liquefaction assessment for a buried glacial stream valley at a Superfund site offshore of Tacoma, Washington: Proceedings for Geo-Institute ASCE Geotechnical Earthquake Engineering and Soil Dynamics III, Geotechnical Special Publication No. 75, Reston, Virginia.

Womack, W.R., J. Volberding, and L. Johnson, 1998, Geotechnical case study SevenUp Pete Joint Venture, McDonald Gold Project: Northwest Geology, v. 28, p. 53-89.

Cameron D.P., and B.R Bronson, 1997, Leach facility construction on placed rockfill overburden: Proceedings of the Fourth International Conference on Tailings and Mine Waste, Tailings and Mine Waste, Colorado State University, A.A. Balkema.

Womack, W.R., J. Volberding, and L. Johnson, 1997, Glacial geology and landslides at the SevenUp Pete site, Montana: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., and D.J. van Zyl, 1997, Geological uncertainty and risk: Short course presented at Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 1997, Historical perspective of river management activities and their cumulative effects: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., 1996, Montana landslides; diagnosis, prevention, and cure: Short course presented at Montana Joint Engineers Conference, Fairmont.

Hutchison, I.P.G, M.L Leonard, and D.P. Cameron, 1995, Remedial alternatives identification and evaluation. Proceedings of the Summitville Forum, Colorado State University, A.A. Balkema.

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Womack, W.R. and G. Rome, 1989, Irrigation waste water triggers severe natural channel erosion: Amer. Soc. Agri. Engineers International Summer Meeting, Quebec.

Womack, W.R., 1984, Detection of shallow abandoned room and pillar workings using high resolution earth resistivity: Proceedings of the National Symposium and Workshops on Abandoned Mine Land Reclamation, p. 42-62.

Womack, W.R., and S.A. Schumm, 1977, Terraces of Douglas Creek, northern Colorado: an example of episodic erosion: Geology, v.5, p. 72-76.

Womack, W.R., 1976, Applications of Thermal Infrared Scanning to Engineering Geology in South Africa: South African Symposium on Remote Sensing.

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W. RAYMOND WOMACK, P.E., P.G.
Principal Engineer
Womack & Associates, Inc.

Slope Stability
Dams
Mining Structures
Foundations
Environmental Projects
River Mechanics

SUMMARY OF EXPERIENCE

Mr. Womack has 30 years experience in geotechnical engineering and engineering geology, providing site investigations, design, and construction supervision. Project experience includes earth fill and tailings dams; landfills; copper and gold mining projects; coal mines; railroads; commercial, municipal, and residential construction; and hazardous waste and ground water pollution sites in 17 states and 7 countries outside the US. Mr. Womack has particular expertise in investigation and mitigation of landslides and other slope stability problems, including seismic and liquefaction studies. He has presented short courses and technical papers, as well as provided expert consulting and witness services in litigations involving foundations, slope failures, and river changes. He has worked extensively in southern Africa, and has also been involved in mining projects in the Republic of Georgia and Kazakhstan.

EDUCATION AND TRAINING

Virginia Polytechnic Institute	B.S. (Geophysics and Geology), 1970
Colorado State University	M.S. (Geology), 1975

REGISTRATIONS & AFFILIATIONS

Professional Engineer in Arizona, Colorado, Montana, Washington, and Wyoming
Professional Geologist in Wyoming
Licensed Monitoring Well Constructor in Montana

American Society of Civil Engineers (ASCE)
Association of Engineering Geologists (AEG)
1988-1989 President, Billings Engineers Club
American Scientific Affiliation (ASA)

PROFESSIONAL HISTORY

Womack & Associates, Inc., Principal Engineer/Engineering Geologist, 1982-Present
Geowest, Inc., Billings, MT, Project Manager, 1979-1982
IntraSearch, Inc. (Spectrum), Billings, MT, Geological Engineer, 1978-1979
Partridge, de Villiers & Associates (South Africa), Engineering Geologist, 1975-1978

TECHNICAL PRESENTATIONS AND PUBLICATIONS

Womack, W.R., 2006, Landslides triggered by Hurricane Stan in western Guatemala: investigation and mitigation in a developing environment: 40th Annual Symposium on Engineering Geology & Geotechnical Engineering, Utah State University.

Mokwa, R., W.R. Womack, and D.P. Cameron, 2004, Quantifying risks of construction in landslide-prone areas: Proceedings of ASCE Geotrans Conf., Los Angeles, Geotechnical Special Publication 126, p. 2010-2019.

Womack, W.R., 2004, River changes and property boundary disputes: Montana Bar Association CLE, Miles City, Montana, also presented at 2005 Montana Association of Registered Land Surveyors Conference.

Womack, W.R., 2004, Engineering volunteerism: Montana Geotechnical Group, MSU Engineering Festival, Bozeman, Montana.

Womack, W.R., 2003, Permitting within a corridor management plan: Great Northern Environmental Stewardship Association Meeting, Kalispell, Montana.

Womack, W.R., and D.P. Cameron, 2003, Risks and consequences of remobilization of ancient landslides: Short course presented at Geohazards Symposium, MSU Engineering Festival, Bozeman, Montana.

Womack, W.R., 2002, Lessons learned from failures and near-failures of water retention facilities in the coal fields of the Northern Great Plains: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 2002, Alteration of Yellowstone River form and habitat over the past 50 years: American Rivers Conference, Billings, Montana.

Womack, W.R., 2001, Response and recovery of the Missouri River downstream of Ft. Peck Dam, with resulting property boundary disputes: Applying Geomorphology to Environmental Management (ed D. Anthony, M. Harvey, J. Laronne, and M. Mosley), Water Resources Publications, Ft. Collins, Colorado, p. 429-456.

Boyd K.F., and W.R. Womack, 2001, Stream channel restoration and the illusion of function: Mine Design, Operations, and Closure Conference, Whitefish, Montana (Also presented at Assoc. Montana Flood Plain Managers Conference).

W.R. Womack, 2000, Effects of management on river form and habitat in Yellowstone County: Montana Flood Plain Managers Conference, Billings (Also keynote speech at Yellowstone River Roundtable, Billings).

Womack, W.R., 1999, Yellowstone River geomorphology: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., F.R. Greguras, G.S. Vick, D.K. Nation, and T. Aldritch, 1998, Hidden hazard: liquefaction assessment for a buried glacial stream valley at a Superfund site offshore of Tacoma, Washington: Proceedings for Geo-Institute ASCE Geotechnical Earthquake Engineering and Soil Dynamics III, Geotechnical Special Publication No. 75, Reston, Virginia.

Womack, W.R., J. Volberding, and L. Johnson, 1998, Geotechnical case study SevenUp Pete Joint Venture, McDonald Gold Project: Northwest Geology, v. 28, p. 53-89.

Womack, W.R., J. Volberding, and L. Johnson, 1997, Glacial geology and landslides at the SevenUp Pete site, Montana: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 1997, Geological uncertainty and risk: Short course presented at Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 1997, An historical perspective of river management activities and their cumulative effects: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., 1996, Montana landslides; diagnosis, prevention, and cure: Short course presented at Montana Joint Engineers Conference, Fairmont.

Womack, W.R. and G. Rome, 1989, Irrigation waste water triggers severe natural channel erosion: Amer. Soc. Agri. Engineers International Summer Meeting, Quebec.

Womack, W.R., 1984, Detection of shallow abandoned room and pillar workings using high resolution earth resistivity: Proceedings of the National Symposium and Workshops on Abandoned Mine Land Reclamation, p. 42-62.

Womack, W.R., and S.A. Schumm, 1977, Terraces of Douglas Creek, northern Colorado: an example of episodic erosion: Geology, v.5, p. 72-76.

Womack, W.R., 1977, Engineering geology for civil engineers: Senior level course at The University of the Witwatersrand, Johannesburg, South Africa.

Womack, W.R., 1976, Applications of thermal infrared scanning to engineering geology in South Africa: South African Symposium on Remote Sensing, Johannesburg.

Author of numerous private reports on geotechnical engineering, engineering geology, and river mechanics.

SLOPE STABILITY

PROJECT	LOCATION
Beartooth Highway Reconstruction	Montana
Dinosaur National Monument Landslide	Colorado
Hecla Grouse Creek Mine Landslides	Idaho
Stibnite Mine	Idaho
PD\Canyon Resources Seven-Up Pete and McDonald	Montana
Zortman Mine	Montana
ASARCO East Helena Smelter	Montana
ASARCO Tacoma Smelter Landfill	Washington
ASARCO Ray Mine	Arizona
ASARCO Murray Smelter	Utah
BNSF Shirley and Savage Projects	Montana
Crown Butte Power Line Corridor	Wyoming
Westmoreland Absaloka Mine	Montana
Stillwater Mine East Boulder Road	Montana
Cambior Carlota Mine	Arizona

Sonora Mine	California
Columbia Falls Aluminum Landfill	Montana
W.R. Grace Vermiculite Tailings	Montana
Consolidation Coal Ash Creek	Wyoming
Canyon Resources CR Kendall	Montana
Tongue River Railway	Montana
Central Montana Railway	Montana
ASARCO Young Mine Zinc Tailings	Tennessee
Billings Heights Sanitary Sewers	Montana
Red Lodge Sewer Outfall Failure	Montana
Wrongful Death Litigation, Butte	Montana
Rimrock Drilling Litigation, Billings	Montana
Mountain View Subdivision, Billings	Montana
Teton Wilderness Landslide	Wyoming
Bozeman Railway Stability	Montana
McClain Creek Slide	Montana
Buffalo Jump Slide	Montana
Cathedral Mountain Slide	Montana
Michael Keaton Residence, Bridger Bowl	Montana
Leon Hirsch Residence, Lima	Montana
Lee Residence, Cromwell Island, Flathead Lake	Montana
Stayner Residence, Big Sky	Montana
Faubert Residence, Big Sky	Montana
Lyman Creek Water Supply Project, Bozeman	Montana
Aspen Grove Subdivision, Big Sky	Montana
Skywood Preserve Subdivision, Big Sky	Montana
Beehive Subdivision, Big Sky	Montana
Moonlight Basin, Big Sky	Montana
Blue Grouse Development, Big Sky	Montana
Beaver Creek, Gallatin County	Montana
Sunwest Subdivision, Madison County	Montana
Bench Ranch, Sunlight Basin	Wyoming
Roger Altman Residence, Jackson Hole	Wyoming
Jackson Hole Ski Area	Wyoming
Red Lodge Mountain Ski Area	Montana

DAMS AND TAILINGS IMPOUNDMENTS

PROJECT	LOCATION
PPL Montana Saddle Dam	Montana
PPL Montana Main Dam	Montana
Hecla Grouse Creek Tailings	Idaho
Westmoreland Absaloka Mine Dams	Montana
ASARCO Young Mine Zinc Tailings	Tennessee
ASARCO Coy Impoundment Failures (karst)	Tennessee
ASARCO E. Helena Smelter Sludge Repository	Montana
Zortman Mine Dams	Montana
Echo Bay Republic Mine Dams	Washington
ASARCO Blackhawk Tailings	New Mexico
ASARCO Mission Tailings	Arizona

ASARCO Ray Mine Dams	Arizona
W.R. Grace Vermiculite Tailings	Montana
McNeil Slough Reservoir	Montana
Bearpaw Reservoir	Montana
Nilan Reservoir	Montana
Hauser Reservoir FERC Expansion Permit	Montana
Thompson Falls FERC Expansion Permit	Montana
Huntley Irrigation Dam	Montana
Worthen Meadows Reservoir, Lander	Wyoming
Chapek Reservoirs, Sheridan	Wyoming
Chevron Carter Creek Gas Plant Impoundment	Wyoming
Glaston Reservoirs, Big Timber	Montana
Upper and Lower Flagstaff Dams	Montana
BLM Reservoirs	Montana
Billings PUD Impoundment	Montana
Yellowstone Country Club, Billings	Montana
Yates Dam	Montana
Lebowa Dam	South Africa
Sterkspruit Dam, Transkei	South Africa
Transkei Dams(25 sites)	South Africa

FOUNDATIONS

PROJECT	LOCATION
Four Seasons Resort, Teton Village	Wyoming
Snake River Lodge, Teton Village	Wyoming
Teton Club, Teton Village	Wyoming
Teton Lodge, Teton Village	Wyoming
Gondola Restaurant, Teton Village	Wyoming
Bridger Center, Teton Village	Wyoming
Cody Center, Teton Village	Wyoming
Rendezvous Peak Lodge, Teton Village	Wyoming
Granite Ridge Subdivision, Teton Village	Wyoming
Grouse Creek Mill and Crusher	Idaho
ASARCO E. Helena Storage Tanks	Montana
ASARCO Lead Battery Recycling Plant	North Carolina
Murray Pacific Log Yard, Tacoma	Washington
Zortman Mine Water Treatment Plants	Montana
Zortman Mine Cable Belt Conveyor	Montana
Western Energy Housing Studies, Colstrip	Montana
ASARCO Ray SX-EW Plant	Arizona
Navajo Bridges, BIA	Arizona
Faith Chapel Church, Billings	Montana
Michael Keaton Residence, Bridger Bowl	Montana
Chambless Ranch, Bridger Bowl	Montana
Leon Hirsch Residence, Lima	Montana
Four Corners Ice Palace, Bozeman	Montana
Koch Materials, Laurel	Montana
Moonlight Basin, Big Sky	Montana
Russell and Karen Fagg Residence, Billings	Montana

Stone Crop Subdivision, Jackson Hole	Wyoming
Crescent H Ranch, Jackson Hole	Wyoming
Thurston Residence, Jackson Hole	Wyoming
Roger Altman Residence, Jackson Hole	Wyoming
Teton Springs Development	Idaho
Warbonnet Subdivision, Billings	Montana
Northern Cheyenne Housing	Montana
Sheridan V.A. Hospital	Wyoming
Spring Creek Subdivision, Bozeman	Montana
Safeco Insurance, Great Falls	Montana
State Farm Insurance, Bozeman and Miles City	Montana
Intermountain Foods, Bozeman	Montana
Aldworth Construction, Bozeman	Montana
Briarwood Subdivision, Billings	Montana
Drummond School	Montana
Independent School, Billings	Montana
Malta High School	Montana
Glasgow High School	Montana
Jackson Hole High School	Wyoming
Wilson High School	Wyoming
Homestead Post Office, Billings	Montana
Hysham Water Treatment Plant	Montana
Kandisi River Bridge	Kenya
Moffat College Library	Kenya
Bukaleba Clinic and School	Uganda
Pretoria Hospital	South Africa
Urban Beltway Roads and Bridges, Johannesburg	South Africa
Dwangwa Sugar Mill	Malawi

ENVIRONMENTAL AND MINING PROJECTS

PROJECT	LOCATION
ASARCO Yak Tunnel CERCLA Site, Leadville	Colorado
ASARCO E. Helena Smelter CERCLA site	Montana
ASARCO Tacoma Smelter CERCLA site	Washington
ASARCO Omaha Smelter CERCLA site	Nebraska
Murray Pacific Log Yard, Tacoma	Washington
Murray Smelter, Salt Lake City	Utah
Crown Butte Land Application	Montana
Zortman Waste Repositories	Montana
Stillwater Mine Land Application	Montana
ASARCO Lead Battery Recycling Plant EA	North Carolina
EXXON Refinery Interception Drain, Billings	Montana
PPL Montana Interception Drains, Colstrip	Montana
PPL Montana Fly Ash, Colstrip	Montana
Rosebud Power Fly Ash, Colstrip	Montana
NRCS Animal Waste Projects	Montana
Columbia Falls Aluminum Landfill	Montana
Getter Trucking Facilities EA	Wyoming, North Dakota, Montana
Lander Oil Field	Wyoming

Winkleman Dome Oil Field	Wyoming
Hardscrabble Oil Field	North Dakota
Four Eyes Oil Field	North Dakota
Brush Lake Oil Field	Montana
Landtech Injection Wells	Montana and North Dakota
Balco Injection Well and Pipelines	North Dakota
Pacific Recycling, Billings	Montana
Fremont County Abandoned Mines	Wyoming
Montana Abandoned Mines	Montana
Elkhorn Abandoned Mine/CERCLA	Montana
Alladin Tipple Reclamation	Wyoming
Underground Storage Tanks	Montana
Lewistown Clay Reclamation	Montana
Livingston Gravel Reclamation	Montana
Northern Tier Pipeline	Washington, Montana
Zortman Mine Goslin Gulch	Montana
Phelps-Dodge Seven Up Pete	Montana
Phelps-Dodge McDonald	Montana
Canyon Resources CR Kendall	Montana
Canyon Resources CR Briggs	California
Cambior Carlota	Arizona
Bolnisi Madneuli Mine	Republic of Georgia
Jezkazgan SX-EW	Kazakhstan
Montco Project, Tongue River	Montana
Wesco Cook Mountain	Montana
Meridian Cook Creek projects	Montana
Consolidation Coal Otter Creek	Montana
Westmoreland Absaloka	Montana
Western Energy and Montana Power Colstrip	Montana
Arch Youngs Creek	Montana
Bull Mountains	Montana
Meridian Circle West Project	Montana
Ft. Union mine	Wyoming
Consolidation Ash Creek	Wyoming
Carrizozo	New Mexico

RIVER MECHANICS

PROJECT	LOCATION
Yellowstone River Cumulative Impact Assessment	Montana
BNSF Yellowstone Channel Training Assessment	Montana
Clark Fork Litigation, Missoula	Montana
Yellowstone Litigation, Sidney	Montana
Missouri River Litigation, Culbertson	Montana
Horse Creek Erosion, Forsyth	Montana
Careless Creek Erosion, Musselshell County	Montana
Yellowstone Access Sites	Montana
Sweetgrass Creek Reclamation	Montana
Riverfront Park Litigation, Billings	Montana
Big Horn Litigation, Custer	Montana

Langman Litigation, Yellowstone River	Montana
Clarks Fork Yellowstone Boundary Dispute	Montana
Douglas Creek Erosion, Rangely	Colorado
Rock Creek Erosion, Carbon County	Montana
Two Medicine Canal, Blackfoot Reservation	Montana
Huntley Irrigation Diversion	Montana
Alder and McGinnis Erosion, Blackfoot	Montana
Carter Gulch Channel Reclamation, Zortman	Montana
Ruby Gulch Channel Reclamation, Zortman	Montana
Huntley Flood Dike	Montana
Sun River Boundary Dispute	Montana
Bayeux Channel Stabilization	Haiti

FIRM PROFILE

Client service – the ability to meet the needs and exceed the expectations of our clients with respect to performance, budget, and schedule – is one of the reasons that Shannon & Wilson has been in business for over 50 years.

Shannon & Wilson was established in 1954. We are an employee-owned environmental and geotechnical and natural resource consulting firm consisting of 220 scientists, engineers and support personnel in our offices in Seattle and Richland, Washington; Anchorage and Fairbanks, Alaska; Portland, Oregon; Saint Louis, Missouri; Denver, Colorado, and Jacksonville, Florida.

Our Natural Resources Group specializes in wetland studies, fisheries investigations, stream restoration, threatened and endangered species studies, wildlife studies, habitat evaluation, environmental documentation, and permitting. Our natural resources staff works with our engineers and hydrogeologists to address environmental issues that can impact projects. Our relationships with agencies help us acquire permits for projects that may impact wetlands, streams, threatened and endangered species, or sensitive areas in a timely and cost-effective manner.

Our experience is demonstrated through our success on hundreds of natural resource projects for public and private clients.

NATURAL RESOURCE SERVICES

Shannon & Wilson provides unique solutions for each specific project and individualized, client-focused service. We focus on the critical elements of a project to assure that it is accomplished on schedule and budget and to the satisfaction of all interested parties.

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Our range of natural resources services include:

- Permitting/Regulatory Compliance
- Wetlands
- Plant and Animal Surveys
- Fisheries/Stream Studies
- Habitat Surveys and Restoration
- Water Quality Analysis
- Stormwater/Watershed Management
- Biological Assessments
- SEPA/NEPA studies

SAINT LOUIS OFFICE

Since its founding in 1954, the firm has successfully completed over 20,000 projects, located in all 50 states and throughout the world. Approximately 3,000 of these projects have been completed by our Eastern Region headquarters in Saint Louis.

Shannon & Wilson offers a complete staff of professional geotechnical engineers and geologists, technicians, and support personnel. Our personnel are adept at developing project scope and planning exploration programs, directing field drilling and sampling operations, completing laboratory testing, and performing engineering analysis, all of which result in practical design and construction recommendations.

In addition to our design capabilities, Shannon & Wilson excels in construction observation and management, working on site with contractors and subcontractors and helping them identify and resolve construction problems. This has been a key to our success in engineering cost-effective, constructible designs. Often we act as the owner's design and site representative, reviewing plans and specifications, overseeing construction, approving invoices and quantities, reviewing change orders, and providing field direction.

MURRAY L. MEIERHOFF, CHMM
Vice President
Office Manager and Environmental Group Manager

EDUCATION

M.A., Aquatic Biology, University of Missouri - Columbia, 1977
B.A., Zoology, University of Missouri - Columbia, 1974

REGISTRATION

Master Certified Hazardous Materials Manager, Institute of Hazardous Materials Management, 1993
HAZWOPER Supervisor Training, 1987
Corps Wetland Delineation, Institute for Wetland & Environmental Education & Research

PROFESSIONAL ASSOCIATIONS

Adjunct Professor at Maryville University, 1999 - 2003
Gateway Society of Hazardous Materials Managers
Water Environmental Federation
Society of Wetland Scientists

PROFESSIONAL SUMMARY

Mr. Meierhoff has extensive academic background in aquatic ecology, ichthyology, invertebrate zoology, and aquatic botany. He has 20 years experience dealing with issues in aquatic biology, ecology, and limnology. He has conducted more than 30 biological surveys of lakes and rivers in Illinois, Missouri, Pennsylvania, Kansas, Mississippi, Alaska, and Iowa. These surveys have included assessments of water and sediment chemistry; nutrient balances; and populations of plankton, benthos, fish, and aquatic macrophytes. He has conducted work in support of site-specific water quality variances for clients with problem discharges of heated water, fluoride, chloride, and ammonia-nitrogen. He has also conducted ecological risk assessments in support of the Iowa Department of Environmental Quality efforts to characterize the hazards associated with the (then) top-priority CERCLA site in the state of Iowa.

RELEVANT EXPERIENCE

- Project Manager for studies was to characterize water-quality-related impacts to the fish and benthic macroinvertebrates populations in Saline Creek in northern Jefferson County, Missouri from wastewater treatment plant discharges on Saline Creek. Biological monitoring was conducted at six locations chosen to bracket the multiple WWTP discharges on the stream. Sampling locations were carefully selected to be comparable in habitat diversity. Our stream survey also included chemical sampling conducted around-the-clock, to characterize the diurnal dissolved oxygen and nutrient pulse in the stream.

- Project Manager for a water quality / aquatic biology investigation of an urban stream watershed for the City of Sunset Hills in Missouri. Impacts to receiving stream water quality and aquatic biology from non-point runoff from salt-treated streets in the winter were an issue in the development of a new city maintenance / storage facility. We collected snowmelt runoff samples to document the impacts of the street runoff before and after the completion of a new salt storage facility. Our testimony at a public hearing, and final report allowed the proposed developments to proceed as planned.

- Project manager for a habitat assessment to reduce fish attraction at an eastern Missouri casino complex. The river hydrology at the casino resulted in an accumulation of large woody debris under the boat, which attracted numerous fish species including shovelnose sturgeon. We developed a plan to enable the casino to minimize this accumulation, and worked with them to remove the existing debris with minimal impacts to the existing fish.

- Principal-in-Charge and Project Biologist for the Piasa Creek Watershed Restoration Project in Madison, Macoupin, and Jersey Counties, Illinois. The project area is a 78,000-acre watershed along the Mississippi River. Shannon & Wilson surveyed and recorded habitat and ecosystems within the watershed and identified areas for restoration. Both structural and non-structural measures were evaluated for reduction of sediment load.

- Field Team Leader for the collection of approximately 200 individual samples of water, soil, sediment, benthic macroinvertebrates, and fish from the island of Amchitka (in the Aleutian Islands) for the Alaska COE in September 1998. This project was an ecological risk assessment and study of water and sediment quality, benthic macroinvertebrates, and fish in seven streams on the eastern quarter of the island. These seven streams included five potentially impacted streams, and two reference (or control) streams. This portion of the island had been impacted by drilling programs and underground nuclear detonations conducted by the U.S. Atomic Energy Commission from 1965 to 1972. Potential contaminants included heavy metals from drilling additives, hydrocarbons from the drilling process, and radionuclides from the nuclear events. Since the entire island is uninhabited, our contract included full-scale staffing and provisioning of an independent field camp on the island, and complex health & safety issues due to the presence of unexploded WWII ordnance on the island.

- Project Manager for three aquatic biology / water quality investigations conducted for a major Missouri mining company. These investigations documented the impacts (if any) to the receiving streams from discharges associated with the mining processes. Benthic macroinvertebrates in the streams were collected and identified to determine the levels of impact to the receiving streams. Results from these investigations identified both mine-related and non-mine-related water quality impacts to the receiving streams. Our

conclusions allowed the company to alter their processes to reduce the observed impacts, and to discuss management and discharge issues with other property owners in the watersheds.

- Project Manager for biological stream monitoring following an inadvertent release of rock fines into a pristine Ozark stream in southeast Missouri. This work successfully supported our client's position that impacts to the aquatic ecology of the receiving stream from the release were limited in duration and extent.

- Conducted site investigations in Alaska for hydrocarbon contamination at several locations on the Elliot Highway northwest from Fairbanks, AK. This effort included negotiations with the state regulatory agency regarding acceptable remedial measures for contaminated soil and groundwater in a permafrost area. Biological monitoring was conducted to estimate the downstream extent of impacts from spills of diesel fuel.

- Project Manager for biological and chemical stream monitoring at a coal preparation facility in south central Illinois, including characterizing the benthic macroinvertebrate and fish communities in a receiving stream. This monitoring program successfully supported a site-specific water quality variance for elevated concentrations of fluoride in the discharge. Our client realized savings of more than $500,000 by acquiring the variance rather than constructing a treatment facility to remove fluoride.

- Prepared water quality and aquatic ecology sections of an environmental impact statement for the Tennessee Department of Transportation for a proposed port and industrial park where at least 12 threatened or endangered species were found; and for the Pennsylvania Department of Transportation for a proposed realignment and replacement bridge in a historically sensitive area of Bucks County.

- Collected, identified, enumerated, and tabulated the phytoplankton, periphyton, rooted macrophytes, zooplankton, macrobenthos, fish, and other aquatic vertebrates found in the Salt River in northeastern Missouri for the University of Missouri at Columbia under contract to the U.S. Army Engineer District, Saint Louis.

- Initiated a fathead minnow bioassay program designed to test chemicals and mixtures of special interest to Iowa water quality.

- Reviewed and revised Iowa's water quality standards as a member of the Iowa Water Quality Review Subcommittee. This review is mandated by the USEPA for every state every third year.

- Planned and conducted a survey of the aquatic ecology of Cedar River in northeastern Iowa, downstream from the state's top-priority Superfund site. The survey included analyses of the water, sediment, macroinvertebrates, and fish of the Cedar River over a 20-mile reach of the river. The Superfund site included leachate releases containing nitro-anilines, organo-arsenates, and other heavy metals from a veterinary pharmaceutical producer.

- Project Manager for biological and chemical monitoring of an 8-acre lake near Chester, IL, following impacts to the lake from upstream agricultural applications of organo-phosphate pesticides. The non-target organism impact included a total fish kill in the lake, with the loss of a trophy bluegill fishery.

- Project Manager for biological and chemical monitoring of a one-acre lake in Saint Charles County, MO, following impacts to the lake from upstream disposal of pentachlorophenol. Impacts to the lake included a partial fish kill, and loss of fishery resource due to continued bio-accumulation of pentachlorophenol from the soils and sediments.

- Master's Thesis in Aquatic Biology entitled, "Seasonal Fluctuations in the Benthic and Planktonic Communities of the Salt River, Missouri."

WILSON, IHRIG & ASSOCIATES, INC.
ACOUSTICAL AND VIBRATION CONSULTANTS

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Wilson, Ihrig & Associates, Inc. is a world renowned acoustical and vibration consulting firm offering a complete range of professional services associated with acoustics and the control of noise and vibration. As an acoustical consulting firm specializing in transit system and railroad noise and vibration control, Wilson Ihrig draws from 40 years of experience with modern rail systems.

Wilson Ihrig was established in 1966 and currently employs a staff of 21, comprising 13 well-trained and experienced professional specialists in acoustics and vibration, two technicians, a field assistant, and five support personnel. Wilson Ihrig has full capability to provide all aspects of noise and vibration studies and design work for rail and other transportation projects.

Rail Transportation

Wilson Ihrig is a leader in rail transportation noise and vibration control, having worked on over 30 different railroad and transit systems in the USA, Canada, United Kingdom, Australia, Hong Kong, Taiwan, Brazil and Greece. For many of the U.S. transit systems, Wilson Ihrig has served as system wide acoustical consultant from the initial environmental impact phase through the preliminary and final engineering design phases. Wilson Ihrig has consulted on all aspects of noise and vibration studies and design work for rail and other transportation mode projects, including environmental assessments, equipment and facilities specifications, facility planning, station acoustics, vehicle noise and vibration control, and analysis and testing of track support systems. In addition to work directly for rail systems, Wilson Ihrig prepared the "Handbook of Urban Rail Noise and Vibration Control" for the Transportation Systems Center of UMTA (now FTA); and the "Wheel/Rail Noise Control Manual" under TCRP Project C3. Wilson Ihrig developed the prediction methodology currently prescribed for rail transit impact assessment in the Federal Transit Administration guidance manual, "Transit Noise and Vibration Impact Assessment." Today, Wilson Ihrig remains a leader in the rail vibration control field through its work incorporating Tire-Derived Aggregate (tire shreds) into track design for vibration control.

A specialty of Wilson Ihrig is the measurement and evaluation of groundborne vibration and noise from rail transit operations and other sources, including the projection of the expected level of audibility of noise radiated in buildings and the possibility of perception of the vibration by occupants. Wilson Ihrig has the background and experience for effective review of new project situations, both to determine expected groundborne noise and vibration and to determine the expected effectiveness of practical mitigation measures

Environmental Noise and Vibration Impacts Assessment

Wilson Ihrig's experience involving assessment of environmental noise and vibration impacts for transportation systems includes: Alternatives Analyses (AA); Draft Environmental Impact Statements and Reports (DEIS/DEIR); Final Environmental Impacts Statements and Reports (FEIS/FEIR); and Environmental Assessments (EA). Wilson Ihrig has gained considerable experience with the requirements of the California Environmental Quality Act (CEQA), the U. S. National Environmental Protection Act (NEPA) and with noise and vibration criteria established by other governmental and transit agencies. Wilson Ihrig's services include: environmental noise and vibration measurement programs; evaluation of noise and vibration impacts; preparation of technical reports for inclusion in environmental documents; and writing the noise and vibration section of Environmental Impact Reports and Statements.

Measurement and Analysis Capabilities

Wilson Ihrig has decades of experience in measurement, analysis, community impact assessment and design of mitigation for rail system noise and vibration. Wilson Ihrig is fully equipped to do all types of acoustical and vibration measurements, including real time analysis, digital processing of noise and vibration data, statistical analysis and extended surveys, and has available the means to completely evaluate transportation systems, industrial, community and building noise and vibration problems or acoustical characteristics. In addition, Wilson Ihrig's measurement and laboratory analysis equipment has been designed specifically for performing accurate and efficient measurements of rail system noise and vibration. Our many completed measurement programs provide an extensive data base for use in projections associated with environmental impact studies.

PROJECT EXPERIENCE

DM&E Railroad Powder River Expansion Project, Kansas City, MO
Burns & McDonnell
Wilson Ihrig performed a study analyzing the potential ground vibration impacts associated with the future operation of unit coal trains on the Dakota, Minnesota & Eastern (DM&E) Railroad as part of the Powder River Expansion Project. This study included a thorough review of applicable criteria for potential building damage, human response and vibration sensitive industrial, research and medical facilities. The study presented examples of existing ground vibration from train operations at locations in British Columbia, Nevada and California. Also presented were methods used to predict the groundborne vibration from trains and a review of mitigation methods that could be used to reduce the production of wayside ground vibration where necessary. The study concludes with an indication of possible distances of ground vibration impact from train operations with respect to human response and potential building damage, as well as recommendations for additional study to further define the potential impact from the DM&E Powder River Expansion Project.

Union Pacific/Southern Pacific Merger, Fairfax, VA
De Leuw, Cather & Company
Wilson Ihrig performed the environmental noise impact analysis for the proposed UPSP railroad merger in support of the project's DEIS prepared by the STB in accordance with NEPA requirements. The project involved determining the environmental impact associated with merging the activities of these two national railroads covering the western half of the United States. Wilson Ihrig's work involved extensive field reconnaissance to determine the location and quantity of noise sensitive receptors (residences, schools, hospitals) along the mainline routes of the two railroads and adjacent to their rail yards which include intermodal facilities. Field measurements were made by Wilson Ihrig to characterize train and yard noise and improve the noise model used to project off-site noise levels. Noise level predictions were made for potentially affected areas along the railroads' mainlines and adjacent to the rail yards. Noise mitigation was investigated for those areas where noise impacts were indicated by the STB noise criteria. Wilson Ihrig prepared the DEIS text and supporting documentation for the noise impact section and assisted in response to public and agency comments on the DEIS noise section.

CN Rail Environmental Assessments, Ontario, Canada
CN Rail
Development/Review of Provincial (Ontario) "Land Use Policy on Noise and Vibration Levels in New Residential Developments Adjacent to Railways". Wilson Ihrig conducted environmental noise and vibration assessments at over 20 residential areas in Toronto.

Central Puget Sound Light Rail Transit System North Link Preliminary Engineering, Seattle, WA
Puget Sound Transit Consultants
Wilson Ihrig prepared an impact assessment of groundborne vibration from the proposed Sound Transit Light Rail Transit on the University of Washington campus as part of the preliminary engineering phase of the North Link project. Work has involved predicting and mitigating low level, low frequency vibration from a planned subway route under the University of Washington campus, where there is concern that even low levels of vibration will interfere with cutting-edge, optical-based research apparatus. Wilson Ihrig has made vibration propagation and extensive ambient

vibration measurements on the campus, as well as predicted statistical train vibration levels in many laboratories.

Tektronix Campus Vibration Assessment, Portland, OR
Tri-Met Engineers
Wilson Ihrig performed an analysis of ground vibration impacts by the Tri-Met Westside Light Rail Transit on future semiconductor manufacturing and research activities at the Tektronix campus. The analysis included field measurement of trackbed vibration force density levels for the Tri-Met vehicle, and impulse response measurements to determine ground vibration propagation conditions at the Tektronix campus. The results were combined to predict ground vibration at distances up to 600 ft from the track alignment. The work included attendance of meetings between the Tri-Met Engineers and Tektronix.

New York Metropolitan Transportation Authority/Long Island Railroad - East Side Access
Parsons
Wilson Ihrig was the noise and vibration consultant on the Systems Engineering design team for the East Side Access (ESA) project which will bring the LIRR commuter trains into NYC via the Upper East Side of Manhattan and connect under Park Avenue from the north to Grand Central Terminal (GCT). Wilson Ihrig evaluated the groundborne noise and vibration impacts associated with operating commuter trains in new subway tunnels underneath the streets of Manhattan and Queens. The planned subway tunnel will pass underneath numerous residences and other noise and vibration sensitive receptors. As part of this process, Wilson Ihrig made extensive measurements of the vibration propagation characteristics of the geologic strata in Manhattan and vibration measurements to determine the response of buildings potentially affected by the project. Wilson Ihrig was responsible for developing the requirements for groundborne noise and vibration mitigation to be used on the project. Wilson Ihrig was also responsible for acoustic design issues in the LIRR facilities to be built in GCT, with station platforms to be located 140 ft below street level.

Kamloops Railroad Vibration, Canada
Canadian National Railways
Wilson Ihrig analyzed vibration data to determine the cause of excessive ground vibration adjacent to the CNR in Kamloops, Canada. Undulation in the rail due to roller straightener wheel runout was identified as the principal cause of high vibration, and replacement of the rail with lower rail height profile perturbation reduced ground vibration velocity levels about 10 to 15 dB. The problem was identified by narrow band analyses which revealed spectral peaks in wayside vibration coincident with profile wavelengths equivalent to roller wheel diameters.

California High Speed Rail Statewide Program EIR
IBI Group; P&D Consultants, Inc.; EIP Associates, CH2M Hill
Wilson Ihrig conducted the analysis for the regional, environmental noise and vibration impact studies for the California High Speed Rail Statewide Program EIR. The project consisted of five regional corridors:
Sacramento - Bakersfield (Central Valley)
Los Angeles – Bakersfield
Los Angeles - San Diego (Coastal Route)
Los Angeles - San Diego (Inland Empire)Bay Area – Merced
Wilson Ihrig conducted environmental studies based on GIS screening analyses of noise and vibration impacts in accordance with the FRA "High Speed Ground Transportation Noise and

Vibration Impact Assessment" guidelines. The analyses for the five rail corridors determined impacts to sensitive land along 700 miles of proposed High Speed Rail corridor. Specific representative cases were also analyzed in detail for all five corridors for evaluation of noise and vibration impacts to specific types of land use.

Bay Area Rapid Transit District (BART), San Francisco International Airport Extension Preliminary Engineering
Bay Area Transit Consultants
During the environmental and design phases, Wilson Ihrig made projections of the groundborne noise and vibration at residences and buildings adjacent to the BART SFO at-grade, tunnel and aerial alignment. Field measurements were conducted to measure the vibration propagation along the alignment and building vibration responses, using an instrumented hammer attached to the drilling string and inserted into a borehole. Wilson Ihrig also conducted measurements of the building vibration responses at a nearby mobile home park and at single family residences. This test entailed using a vacuum-powered hammer to impact the sidewalk or street in front of the building and measuring the vibration at the ground in front of the building and the floor within the building. The vibration measurements were compared to obtain a measure of the vibration response of the building relative to the ground vibration. During the construction phase, Wilson Ihrig assisted with vibration and noise monitoring at the historic cemetery buildings and structures, and medical and office buildings adjacent to the cut and cover tunnel. Wilson Ihrig made presentations to BART and the Construction Management team to discuss noise and vibration measurements, project limits, etc., and developed construction noise and vibration guidelines for the project, including the monitoring approach used to determine compliance with the allowable limits. Wilson Ihrig also trained personnel in the environmental compliance management team to conduct noise and vibration monitoring and then coordinated daily monitoring location assignments with the team.

Bay Area Rapid Transit District (BART), Warm Springs Extension
Parsons Brinckerhoff Quade & Douglas
As part of the Preliminary Engineering team, Wilson Ihrig was responsible for evaluation of noise and vibration impacts associated with the new 7.8 mile BART extension to Warm Springs (WSX). Projected BART train, operational noise impacts for the adjacent residential areas along the planned alignment and determined appropriate noise mitigation to achieve the project criteria. Wayside noise control included sound walls and sound absorptive treatment. Evaluated noise impacts from ancillary facilities and determined noise control for emergency ventilation fans. Based on extensive vibration measurements within the WSX corridor, projected groundborne vibration impacts to adjacent residences. Evaluated several alternative track-side vibration control measures for their effectiveness in controlling groundborne vibration and their feasibility. Recommended specific measures that could be used to achieve project vibration criteria. Evaluated cumulative noise impact associated with relocation of the freight railroad tracks within the corridor.

Silicon Valley Rapid Transit (SVRT) Line Segment, Preliminary Engineering
HNTB
Preliminary engineering design for the Line Segment of the 16.3 mile Silicon Valley Rapid Transit (SVRT) extension of the Bay Area Rapid Transit (BART) system to San Jose. This is a 9.8 mile segment of the planned extension of the SVRT Project starting at the end of the planned Warm Springs BART Extension Project. The Line Segment alignment includes portions at grade, within retained cut, and on embankment and aerial structure. Work involved prediction of ground vibration from operations using the FTA-approved model, measurement of the vibration propagation

characteristics from the proposed alignment to adjacent properties, including measurements inside existing residential buildings to determine building response, and determining the need for and type of vibration mitigation to achieve criteria. Work also included prediction of airborne noise impacts from BART train operations, and the determination of wayside noise control measures such as noise walls necessary to achieve the project noise criteria. The project also involved evaluating the potential impacts from construction noise and vibration and specifying areas where control measures may be needed.

Silicon Valley Rapid Transit (SVRT) Tunnel Segment Preliminary Engineering
Hatch Mott MacDonald/Bechtel JV
Preliminary engineering design for the Line Segment of the 16.3 mile Silicon Valley Rapid Transit (SVRT) extension of the Bay Area Rapid Transit (BART) system to San Jose. This is a 5.1 mile subway segment of the SVRT Project starting at a portal at the end of the Line Segment and extending through downtown San Jose to a portal before the yard leads and tail track. The project involved determination and evaluation of groundborne noise and vibration impacts. The work included vibration testing, modeling, and analysis. During the project, field measurements were conducted along the planned alignment to determine site-specific vibration propagation characteristics. Predictions of groundborne noise and vibration were obtained using the FTA-approved model. The model included the effects of the tunnel structure on the vibration emission characteristics from the tunnel to the surrounding soil strata. Also included in the model were the effects of different types of building structures encountered close to the alignment. Based on the model predictions, Wilson Ihrig provided recommendations for mitigation measures to achieve the project groundborne noise and vibration criteria. The project also involved evaluating the potential impacts from construction noise and vibration and specifying areas where control measures may be needed.

Los Angeles County Metropolitan Transportation Authority - Metro Red Line Project
Southern California Rapid Transit District; Engineering Management Consultant (PB/DMJM)
Wilson Ihrig has served as the acoustical consultant for both the preliminary and final design phases of this project. Wilson Ihrig tasks have included: survey of existing levels of noise and vibration; projection of noise and vibration levels at nearby buildings; preparation of systemwide criteria and specifications for the control of wayside noise and vibration from construction of the system, operation of the trains and ancillary equipment; preparation of criteria and guidelines for achieving a comfortable acoustical environment in the stations and vehicles.

Metropolitan Atlanta Rapid Transit System
Parsons Brinckerhoff-Tudor; Metropolitan Atlanta Rapid Transit Authority
Wilson Ihrig has served as the systemwide acoustical consultant for the MARTA system from the preliminary environmental review, through the system design and the initial operation of the system. Initially Wilson Ihrig was a subconsultant to PBTB (later PBT), the general engineering consultant and since 1979, the Wilson Ihrig contract has been directly with MARTA. The tasks have ranged from developing projected noise contours from the environmental review of the proposed system to performing vibration propagation measurements at locations along the proposed North Line. Work has included projection of noise and vibration levels at nearby buildings; preparation of systemwide noise and vibration criteria; measurement and analysis of operational noise and vibration; and line structure and station design reviews.

Washington Metropolitan Area Transit Authority - Metro System

De Leuw, Cather & Company
Wilson Ihrig has been providing acoustical consulting services on the design and evaluation of the WMATA Metro system since 1970. Some of the significant tasks that Wilson Ihrig has performed for WMATA include: environmental measurements of existing noise and vibration levels; development of noise and vibration criteria for community noise, vehicles, stations, and ancillary equipment; design of floating slabs; design of way-structures, aerial and subway, for control of wayside community impact; development of rail fixation performance specifications; development and revision of floating slab track support system design; car noise and sound insulation testing and design.

Mission Valley East LRT Project, San Diego
BRW, Inc.
The project involved measurement and analysis of soil vibration propagation characteristics, empirically deriving LRV source characteristics, and formulating special trackwork recommendations to control groundborne noise and vibration. Wilson Ihrig provided extensive support regarding construction noise and vibration impacts for San Diego State University buildings. This included identification of sensitive buildings, projection of construction noise and vibration at buildings, developed measures to achieve acceptable noise and vibration levels during construction, confirming performance of construction noise barriers, and demonstrated resulting noise levels to University and MTDB officials.

San Francisco Muni Third Street Light Rail Project
WPK Third Street Consultants
Wilson Ihrig conducted construction vibration and noise monitoring to determine compliance with construction specifications and city noise ordinance. Extensive measurements and analyses were conducted to determine the effects of soil, track structure, rail conditions, wheel conditions, dynamic building response and other factors on vibration levels from San Francisco Muni Light Rail Vehicle. Wilson Ihrig also made design recommendations for mitigating the impact of groundborne vibration to residences along the planned Third Street light rail alignment.

Valley Metro Rail Central Phoenix/East Valley Light Rail
PBS&J/WE Joint Venture
Wilson Ihrig work has involved Construction Administration, observations, criteria formulation, meetings, and noise and vibration analysis for construction phase. Wilson Ihrig is also conducting remote monitoring of vibration during construction.

Superconducting Super Collider Railroad Vibration Exposure
Lawrence Berkeley National Laboratory
Wilson Ihrig work involved measuring ground vibration produced by railroad trains passing over the proposed alignment of the Superconducting Super Collider in the State of Arizona. This work involved identification of low frequency ground motion caused by the moving static load of the train.

Palo Alto Medical Foundation Railroad Ground Vibration
Taylor Engineering
Acoustical and vibration consultation for expansion of Palo Alto Medical Foundation's proposed building along a railroad track. Wilson Ihrig measured and evaluated ground vibration from trains at

proposed site for the research facility and analyzed the design to minimize structural vibration transmission into medical building.

Ashley Creek US93 Widening, Kalispell, MT
Montana Department of Transportation / Big Sky Acoustics
Evaluation of potential adverse impact at the site of KGEZ radio station due to vibration generated by construction activities during the widening of US93 near Kalispell, Montana. Measurement of vibration-generating characteristics of most construction equipment to be used and of transfer functions between the road and spaces housing sensitive equipment at the radio station. Continuous vibration monitoring during key construction periods.

Transit Projects involving Environmental Impact Analysis

Santa Clara County Transit District - Tasman Corridor Light Rail Transit FEIR/FEIS
Michael Brandman Associates
Wilson Ihrig services on the Tasman Corridor Light Rail Project have included measurement and analysis of environmental noise and vibration impacts, characterization of noise and vibration from the existing light rail system in San Jose, determining vibration propagation characteristics of the soil, and developing noise and vibration control measures. The work was incorporated into the FEIR/FEIS.

Portland Tri-met Hillsboro Extensions EIS
Parametrix Inc.
Wilson Ihrig performed environmental noise and vibration impact analyses for the Hillsboro extension between S.W. 185th Ave and Hillsboro. This work involved a complete alternatives analysis with respect to noise and vibration impact, site noise and vibration surveys, reviews, and recommendations for noise and vibration control. The work was incorporated into the DEIS and FEIS for the project.

Bay Area Rapid Transit District (BART), Pittsburg/Antioch Corridor DEIR, FEIR
Bechtel Civil, Inc.
Evaluation of the potential impact from noise and vibration for 12 alternatives proposed for the 18 mile BART Pittsburg/Antioch Corridor. The following issues were addressed: noise and vibration impact of system operations and project construction, BART and LRT ancillary equipment, and highway and road traffic associated with the project.

Bay Area Rapid Transit District (BART), Dublin/Pleasanton Extension DEIR, FEIR
Woodward-Clyde Consultants (now URS)
Evaluation of the impact due to noise and vibration for various alternatives for the proposed 13.7 mile BART Dublin/Pleasanton Extension, including noise and vibration impacts of project construction, BART vehicle operation, BART ancillary equipment and highway relocation associated with the project.

Bay Area Rapid Transit District (BART), Warm Springs Extension DEIR, FEIR
DKS Associates
Evaluation of the environmental impacts due to noise and vibration for the 7.8 mile Warm Springs Extension of the BART Fremont line. Eight alternatives and several design options for a BART line and three non-BART alternatives were analyzed.

Research Projects

Development of Procedures for the Prediction and Control of Groundborne Noise and Vibration from Rail Transit Systems
U.S. Department of Transportation
For this project, Wilson Ihrig studied methods for the prediction and control of groundborne noise and vibration. Groundborne noise and vibration can be a major source of environmental impact from rail transit systems in both commercial and residential areas. The goals of this project were to: (1) develop procedures to more accurately predict groundborne vibration; and (2) develop optimized methods for controlling groundborne noise and vibration. The study has involved a detailed review of the state-of-the-art, both in the U.S. and abroad; development of mathematical models characterizing transit car trucks, vibration propagation in soil, and soil/structure interaction; development of field procedures for characterizing the dynamic properties of transit car trucks; measurements of groundborne vibration at three transit systems and at the Transportation Test Center in Pueblo, Colorado; and the development of a new prediction procedure for groundborne vibration.

Using the prediction procedure for future transit projects will allow much more accurate pinpointing of the areas where vibration control measures are required. In many cases, it should be possible to reduce the lengths of special vibration control measures such as floating slabs by a significant amount, simply because of more accurate predictions. As part of this project, the prediction procedure was applied to the BRRT B-Route section extending from Reistertown Plaza to the Beltway. The prediction procedure has since been applied to several new transit systems.

Handbook of Urban Rail Noise and Vibration Control
U.S. Department of Transportation
The Handbook of Urban Rail Noise and Vibration Control is an 800-page document covering all aspects of the prediction and control of urban rail noise and vibration. The entire handbook was researched and authored by Wilson Ihrig, drawing on the unparalleled experience of Wilson Ihrig in rail transit noise and vibration control. Much of the material included in the handbook was developed through Wilson Ihrig's numerous transit projects and had not been previously published. The document has been widely distributed since its publication in February 1982. It is generally acknowledged as the most authoritative and comprehensive source available on the topic of rail transit noise and vibration control and has been used by many different transit systems and consultants.

Topics covered in the handbook include: Criteria for acceptable levels of noise and vibration exposure of patrons, the community, and transit employees; Overview of the characteristics of urban rail noise and vibration; Detailed information on the procedures and equipment that should be used to measure rail transit noise and vibration; Control of airborne noise from different types of surface track; Prediction and control of groundborne noise and vibration; Acoustical design of transit

stations; Control of fan and vent shaft and other ancillary equipment noise; Control of pressure transients.

Research Study for TCRP Project C-3 - Wheel/Rail Noise Mitigation
Transit Cooperative Research Program, Transportation Research Board, Washington, D.C.
Wilson Ihrig performed a research study for the Transit Cooperative Research Program (TCRP) investigating wheel/rail noise generation and control for rail transit systems. The goal of the study was to identify practical and cost effective noise control measures that can be applied systemwide by a wide spectrum of transit authorities, and develop procedures for selecting and implementing these technologies. To accomplish this goal, Wilson Ihrig determined, by compilation, analysis and evaluation of the available information, the state-of-the-art regarding practical procedures for reducing wheel/rail noise.

The project involved two phases: (1) determination of the practical state-of-the-art in wheel/rail noise control by an extensive literature review and contact with cognizant individuals in the North American and international transit industry who have conducted research in the field and who have direct experience with tests of methods and procedures, and (2) development of a wheel/rail noise control manual with an effective set of noise control procedures that can be used by the transit industry. The "Wheel/Rail Noise Control Manual", TCRP Report 23, and accompanying software were published in June 1997. The work for C3A involved testing and demonstration of wheel and rail vibration absorbers at participating transit systems. This involved coordination with the transit agencies to install and measure the effect of mitigation measures.

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Principal / Vice President

Education: Ph.D. (1988) in Engineering Science, Mechanical Engineering,
M.S. (1982), B.A. (1972) in Physics and Mathematics,
University of California, Berkeley
Professional Mechanical Engineer, California, License No. 19425

Affiliations: Member, Transportation Research Board,
Committee A1F04 on Transportation Related Noise and Vibration
Committee A2M04 on Rail Transit Design
Chairman of TRB Subcommittee on Rail Transportation Noise and Vibration
Member, National Council of Acoustical Consultants
Member, Acoustical Society of America
Member, American Society of Mechanical Engineers
Member, American Institute of Physics
Member, Institute of Noise Control Engineering

Awards: Pike Johnson Award for Best Paper, Transportation Research Board
Best Paper, Transportation Research Board Committee A1F04

Employment History: Wilson, Ihrig & Associates, Inc. (1973 to Present)

Qualifications: Dr. Nelson has been involved in every aspect of rail transportation noise and vibration control since joining WIA in 1973. His project experience includes ground vibration prediction, ground vibration propagation measurement, modeling subway structure vibration radiation, numerical analysis of track and rail vehicle dynamics, measurement of wheel vibration and flange forces, subway air pressure transient prediction and mitigation, direct fixation fastener specification, measurement of long distance sound propagation conditions, seismic ground disturbance surveys and preparation of noise elements for environmental impact studies. He was instrumental in developing and refining groundborne prediction procedures.

Dr. Nelson is a recipient of the Pike Johnson Award from the Transportation Research Board, and has presented technical papers worldwide.

Project Experience

Transit Cooperative Research Program, Project C3 (1994-1997): Principal Investigator for preparation of the "Wheel/Rail Noise Control Manual", TCRP Report 23, Transportation Research Board. This work involved summarizing the state of the art in wheel/rail rolling and curving noise.

Transit Cooperative Research Program, Project C3A (1997-2000): Principal Investigator for testing and demonstration of wheel and rail vibration absorbers at participating transit systems.

Long Island Railroad ACL Viaduct, New York (2004): Project director for noise and vibration assessment and development of specifications for new track for the ACL Viaduct.

Central Puget Sound LRT System Facilities Design (2004): Ground vibration impact assessment of proposed Sound Transit LRV on University of Washington, including field testing and theoretical modeling of ground vibration propagation.

Long Island Railroad East Side Access Project, New York (2001): Used a seismic reflectivity model to predict the vibration responses of schist granite and overlying soil layer.

Queensland Rail, Australia (2000-2001): Review of wheel/rail noise control procedures employed by the Queensland Rail. Principal issues concerned wheel squeal, lubrication techniques, maintenance issues, rail fastener stiffness, contact conditions, geometrics, track gauge, wheel and rail profiles, humidity, and other factors.

Union Pacific/Southern Pacific Merger Environmental Assessment (1996-1997): Assessed the noise impact related to merger of the Union Pacific and Southern Pacific railroads.

Los Angeles County Metropolitan Transportation Authority (1999): Performance of environmental noise and vibration measurements, measurement and prediction of vibration transfer functions from tunnel invert to multi-story structures, review of trackwork specifications for floating slab vibration isolation systems, measurement of floating slab responses, and prediction and control of subway air pressure transients. Development of specifications for a soft track vibration isolation system.

San Francisco Bay Area Rapid Transit System (1973-2005): Measurement of subway pressure transients, wheel shock, vibration and strain, and lateral flange forces, review of direct fixation track fastener, running rail, floating and ballast mat specifications for Dublin-Pleasanton, Pittsburg-Antioch, and Colma Extensions, advisor regarding BART A&B Car Rehab Program.

Washington Metropolitan Area Transit Authority (1973-2004): Performance of environmental noise and vibration surveys, predictions of groundborne noise and vibration, measurement of transit vehicle noise and ground vibration, prediction and control of subway air pressure transient magnitudes and rates of change, tunnel portal design, measurement of aerial structure noise for various direct fixation fasteners, development of a high frequency direct fixation fastener vibration isolation testing apparatus and procedure, qualification testing of direct fixation fasteners.

Metropolitan Atlanta Rapid Transit Authority (1975-1995): Prediction and control of subway air pressure transient magnitudes, prediction of vibration impacts at the Northside Hospital, prediction of pedestrian induced bridge vibration.

Portland Tri-Met Westside Extension, Portland, Oregon (1989-1999): Developed a vibration impact element for environmental documents, measuring wayside noise and vibration, analyzing embedded track designs, including finite element analysis, reviewing rail corrugation mitigation methods, recommending noise and vibration mitigation provisions, and attending public meetings. Recent work includes detailed characterization of ground vibration forces for embedded and ballasted track.

San Francisco Municipal Railway (1991-1992): Assisted MUNI engineers with noise control provisions for San Francisco Cable Car, including noise reduction for depression beams.

Resilient Rail Fastener Study for Elevated Structure Noise Control, New York City Transit Authority, U.S. Department of Transportation (1984-1988): Extensive testing in New York to determine the effectiveness of resilient rail fasteners in reducing elevated structure noise. Work included recommending stiffness characteristics, assistance in developing a specification for procurement of rail fasteners, field testing, and laboratory testing that included development of a high frequency test apparatus and procedure for evaluating fastener isolation characteristics.

Prediction Procedures for Groundborne Noise and Vibration from Rapid Transit Systems, U.S. Department of Transportation (1980-1984): Developed a comprehensive prediction procedure for groundborne noise and vibration from rail transit systems. Work included a review of the state-of-the-art, preparation of an annotated bibliography, theoretical and experimental studies, and field testing.

Subway Structure Vibration Radiation (1975-1986): Developed analytical model for far field seismic responses to point loads directed against the inner surface of a lined hollow tube in an infinite elastic medium. The model was applied to prediction of ground vibration from subway tunnels, and used for determining vibration coupling losses as a function of tunnel wall thickness. The model was implemented in Fortran at Wilson, Ihrig & Associates, Inc. for the U.S. DOT as part of the development of prediction procedures for rail transit systems.

Development of Transfer Function Testing of Soils (1980-1984): Transfer function procedures were developed for measuring dynamic Green's functions for soils. These procedures include a load cell and multiple geophone receivers at various distances. The data allow direct prediction of vibration responses in soils due to point sources, and, using numerical integration procedures, the data are used for prediction of the response due to line sources such as trains. The procedure is applied to surface as well as downhole sources. This work was performed at Wilson, Ihrig & Associates, Inc., for the US DOT.

Transportation Test Center, Pueblo, CO (1983-1990): Ground vibration propagation testing at the transit test loop, measurement of mechanical impedance of the MARTA C-Car prototype, measurement of ground vibration and trackbed force spectra for the MARTA C-Car prototype, Portland Tri-Met prototype, and the NFTA prototype vehicles.

Toronto Transit Commission (1975): Assisted in reviewing ground vibration data for the purpose of identifying reasons for efficient long distance ground vibration propagation in response to complaints at ranges up to 800 feet from subways. The work included a limited theoretical analysis of tunnel vibration radiation and propagation.

Baltimore MTA (1985-1988): Vibration propagation testing for predicting surgical theater vibration magnitudes, measurement of groundborne noise and vibration from BRRT vehicles.

Subway Air Pressure Transient Prediction and Control (1975-1986): A procedure was developed for predicting subway air pressure transients, using the low frequency acoustic response of the tunnel, friction factors for the tunnel wall and train sides, conservation laws for air flow about the train, and test data collected at various systems. The tunnel is modeled as an acoustic delay line with reflections, and includes effects due to cross passages and flared transitions. The model has been used for predicting pressure transients at the Washington Metropolitan Area Transit Authority, the Metropolitan Atlanta Rapid Transit Authority, the Baltimore MTA, and at the San Francisco Bay Area Rapid Transit Systems. The method can be used for assessing the influence of cross-passages and flared entrance transitions for controlling pressure magnitude and rate of rise.

Tunnel Pressure Transient Measurements (1974-1980): Tunnel wall and vehicle interior pressure during motion of rail transit trains in subways was measured at the San Francisco Bay Area Transit System. These data were used for validating a computer model developed by Associated Engineers, Inc. Custom instrumentation was designed and developed. Later measurements were performed at the Washington Metropolitan Area Transit Authority to determine the cause of intertunnel CMU wall and cross-passage door failures. Later, measurements were performed at the San Francisco Bay Area Rapid Transit System's transbay tube to determine the cause of death due to smoke inhalation during a fire.

Kamloops Railroad Vibration Study (1988): Performed analysis and review of vibration data to determine the cause of excessive ground vibration adjacent to the Canadian National Railway in Kamloops, Canada. Waviness in the rail due to roller straightener wheel runout was identified as the principal cause of high vibration, and replacement of the rail with lower rail height profile perturbation reduced ground vibration velocity levels about 10 to 15 dB. The problem was identified by narrow band analyses which revealed spectral peaks in wayside vibration coincident with profile wavelengths equivalent to roller wheel diameters. This work was performed at Wilson, Ihrig & Associates, Inc., for the Canadian National Railway system.

Centex Cement, Railroad Vibration Study, Beale AFB, Marysville, CA (1992): Prediction of vibration due to aggregate trains at the Beale AFB metrology and calibration laboratory. The work included measurement of long range ground vibration from freight trains.

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National Science Foundation Fellowship Recipient (1988-1991)
B.S. (1988) in Mechanical Engineering, University of California at San Diego (*Summa Cum Laude*)
M.B.A. (2000), Saint Mary's College of California (*Summa Cum Laude*)

Affiliations: Member, Acoustical Society of America
Member, National Council of Acoustical Consultants

Employment History: Wilson, Ihrig & Associates, Inc. (1992 to present)
University of California, Berkeley (1988 - 1992)

Qualifications: Since 1992, Mr. Watry has specialized in the control of noise and vibration from rail transit systems. He has been involved in projects concerning rail transit systems in the San Francisco Bay Area, Los Angeles, Washington, D.C., and Portland, Oregon. His project experience has ranged from the initial environmental phase through the final design of trackwork, and noise and vibration field and/or design work. He has made many measurements of various types of noise and vibration and also has experience measuring the vibration propagation characteristics of soils.

Project Experience

Hong Kong Mass Transit Railway (1997-2002): Assisted with extensive measurement program of noise from rail system on the Tsing Ma Bridge.

San Francisco Municipal Railway – New Central Subway Project (2003): Oversaw and participated in work to predict future groundborne noise and vibration levels from new subway system. Project involved developing innovative measurement technique to obtain subterranean vibration data using existing de-watering wells. Groundborne noise and vibration levels were predicted in nearby residences.

San Francisco Municipal Railway - Third Street Light Rail Project (2001): Calculated future vibration levels along new rail alignment, accounting for MUNI vehicle characteristics and speed, regional soil properties, and structural vibration amplification. Reviewed vibration criteria used for Environmental Impact Statement and analysis supporting EIS findings.

San Francisco Municipal Railway B N-Line Rail Replacement Conceptual Engineering Report (1998): Measured and assessed vibration in areas with reported high vibration levels. Worked with Parsons-Brinckerhoff track designers to determine replacement track designs and maintenance practices that will reduce future vibration levels. Made controlled measurements to assess the performance of a commercially available vibration isolation system, DS-ISO-RAIL.

San Francisco Municipal Railway B Noise and Vibration Measurements for Breda C.F. (1998): Measured wayside vibration levels to determine effects of modified Breda LRV2 primary suspension on ground vibration. Extensive testing program controlled for vehicle speed and loading, track fixation, and underlying soil conditions. Wayside noise measurements and analysis assessed effectiveness of modified propulsion system software at reducing tonal noise.

San Francisco Municipal Railway B LRV2 Noise Study (1997): Measured sound intensity from all propulsion system components to located primary source of wayside tonal noise.

San Francisco Municipal Railway B LRV2 Vibration Study (1997): Measured and assessed vibration levels around the MUNI systems. Empirically derived both Breda LRV2 and Boeing SLRV train force density levels and conducted modal analysis testing of vehicle truck dynamics. Work led to redesign of vehicle's primary suspension to reduce vibration. Conducted measurements to determine wood-frame building structural amplification.

Santa Clara VTA Vasona Corridor LRT Vibration Study (2000-2002): Final design vibration predictions and mitigation recommendations. Predictions accounted for VTA train, local soil properties, and specific building types along the corridor. Vibration mitigation requirements led to the design, development and testing of track resiliently supported by shredded, recycled tires.

San Francisco Bay Area Rapid Transit - San Francisco Powell Street Station (1999): Empirically characterized station acoustical environment and and recommended number of acoustically absorbing panels that could be removed without degrading PA system performance.

Caltrain CEMOF (Lenzen Yard) Project (2002): Measured the existing ambient noise, characterized the ambient noise sources, predicted and assessed sound levels from future yard activity for several alternative wall designs, and presented the findings to an Oversight Committee.

Central Puget Sound LRT System Facilities Design (2000-2005): Predicted and mitigated low level, low frequency vibration from a planned subway route under the University of Washington campus, including vibration propagation and ambient vibration measurements.

Los Angeles County Metropolitan Transportation Authority B Metro Red Line Project (1993-1995): Identified noise and vibration sensitive buildings and measured ambient noise and vibration for proposed alignment alternatives. Conducted analysis to determine groundborne noise and vibration levels due to transit trains. Empirically determined vehicle force density level. Formulated special trackwork recommendations to control groundborne noise and vibration.

Wilson, Ihrig & Associates B Research Project (1997): Measured and assessed the effectiveness of Clouth AVibrex 1000" Ballast Mat in reducing groundborne vibration.

San Francisco Bay Area Rapid Transit Extensions Program (1992-1998): Identified noise and vibration sensitive buildings and measured ambient noise and vibration for proposed train alignments.

São Paulo Metrô B Extensão da Linha Paulista (1997-1998): Coordinated and conducted field measurements and analysis of soil vibration propagation characteristics for metro rail extension.

APPENDIX 2

PRELIMINARY PROPOSAL OF RESEARCH TO ASSESS POTENTIAL IMPACTS OF THE TONGUE RIVER RAILROAD ON PALLID STURGEON AT THE MILES CITY FISH HATCHERY

Preliminary Proposal of Research to
Assess Potential Impacts of the Tongue River Railroad on Pallid Sturgeon
at the Miles City State Fish Hatchery

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February 2006

After discussions regarding the Tongue River Railroad (TRR) on February 1 2006, it was requested that I write a brief overview of studies that could be conducted to determine the impact of the TRR on pallid sturgeon at the Miles City State Fish Hatchery (MCSFH). The impacts of the TRR may differ at different life stages.

Pallid sturgeon broodstock are maintained at the MCSFH for approximately 2 to 3 months prior to spawning. These females are released back into the wild within one week of spawning. The length of time required for wild adult pallid sturgeon to become habituated to a stressor, such as the potential vibration or noise associated with the TRR, is unknown. However, I am concerned that, given the short time these fish are present at the hatchery, the females will not become habituated to the potential stress of the TRR. It has been shown in modern teleosts that stress can impede reproduction in fishes by reducing gamete and/or progeny quality (e.g., Campbell et al. 1994; Pankhurst and Van der Kraak 1997; Semenkova et al. 1999; Schreck et al. 2001), increasing the incidence of gonadal atresia (e.g., Clearwater and Pankhurst 1997; Pankhurst and Van der Kraak 1997; Cleary et al. 2000), and compromising immune function (e.g., Georgiadis et al. 2001). Stress may also lead to direct mortality (Schreck 2000).

Pallid sturgeon embryos hatch in approximately 5 to 7 days at MCSFH. A portion of the young-of-year are released into the Missouri River in the fall, while the remaining young-of-year are reared at the facility and released in the early spring. The TRR may also have impacts on embryo development and larval and juvenile growth and survival. These fish may remain in the hatchery long enough to become habituated to the TRR, but there is no literature describing habituation to a stress for sturgeon.

The challenge in assessing the impacts of the TRR on pallid sturgeon is mimicing the vibration/noise that the individuals would experience in the hatchery. This aspect of the experimental design would need to be determined and designed by someone familiar with hearing and noise issues with fishes. The experiments proposed below are designed to 1) collect immediate information needs to implement the studies, 2) assess whether simulation of the TRR will induce a stress response in pallid sturgeon, and 3) if simulation of the TRR does induce a stress response, determine the physiological effects of that stress on the reproduction, development, growth, survival, and, potentially, the immune function of pallid sturgeon. This work could be completed in 2 years.

Study Objectives:

1) *Collect immediate information needs to implement studies.* Critical information includes the current background vibration/noise levels experienced by pallid sturgeon from operation of the hatchery, and the existing railroad and the vibration/noise that would be experienced by pallid sturgeon from the TRR.

2) *Assess whether simulation of the TRR will induce a stress response in pallid sturgeon.* This should be conducted with both adult and juvenile pallid sturgeon. Adult shovelnose sturgeon may be used as a surrogate for pallid sturgeon adults. These experiments may be conducted at the Bozeman Fish Technology Center (BFTC).

Adult shovelnose (n=6) during oocyte maturation (June) will be exposed to vibration/noise that simulates the TRR at the intervals mimicing the proposed train schedule for a 24 hour period. Control fish (n=6) will be maintained in a tank under identical conditions as the treatment fish except they will not be exposed to vibration/noise. Blood will be collected from the caudal vasculature at time 0 (when fish are placed into the treatment or control tanks), 1, 6, 12, 24, and 48 hours. Plasma cortisol, glucose, lactate dehydrogenase, triglycerides, albumin, alkaline phosphatase, alanine transferase, ammonia, aspartate aminotransferase, carbon dioxide, and phosphorus will be measured by radioimmunoassay or blood chemistry analyzer. These blood plasma parameters have been shown to be physiological indicators of stress and tissue trauma in pallid sturgeon (Barton et al. 2000; Webb and Allert, unpublished). Plasma parameters will be compared by analysis of variance (ANOVA) within and between treatments over time.

Juvenile pallid sturgeon (n=30 per tank) will be exposed to vibration/noise that simulates the TRR at the intervals mimicing the proposed train schedule for a 24 hour period in triplicate. Control fish (n=30 fish per tank) will be maintained in a tank under identical conditions as the treatment fish except they will not be exposed to vibration/noise. Blood will be collected from the caudal vasculature at time 0 (when fish are placed into the treatment or control tanks), 1, 6, 12, 24, and 48 hours. Plasma will be pooled and the same plasma parameters described above will be measured. Plasma parameters will be compared ANOVA within and between treatments over time.

The results of these two experiments will determine whether the TRR will induce a stress response in pallid sturgeon juveniles and shovelnose sturgeon adults. If a stress response occurs in the shovelnose sturgeon adults, it is safe to assume that the stress response would also be elicited in pallid sturgeon adults.

3) *If simulation of the TRR does induce a stress response, determine the physiological effects of that stress on the reproduction, development, growth, survival, and, potentially, the immune function of pallid sturgeon.* The stress response has been described in sturgeon (Sangalang et al. 1971; Barton et al. 2000; Belanger et al. 2001; Bayunova et al. 2002; Lankford et al. 2003; Webb, unpublished data), however there is little information on the physiological effects of stress. Adult shovelnose sturgeon may be used as a surrogate for pallid sturgeon adults. These experiments may be conducted at the BFTC.

Adult shovelnose (n=6) during oocyte maturation (April - spawning) will be exposed to vibration/noise that simulates the TRR at the intervals mimicing the proposed train schedule. Control fish (n=6) will be maintained in a tank under identical conditions as the treatment fish except they will not be exposed to vibration/noise. Oocyte maturation will be monitored and females will be spawned according to the protocols described for pallid sturgeon. Once the eggs are fertilized, they will be placed in McDonald jars for incubation with or without vibration/noise based on their respective treatment groups (i.e. eggs from females exposed to vibration/noise will be incubated in jars exposed to vibration/noise, while eggs from females not exposed to vibration/noise will not be exposed to vibration/noise during incubation). Ovulation success, rates of atretia (resorption of developing eggs), fertilization success, developmental

abnormalities, and hatch success will be quantified. These endpoints will be compared between the control and treatment groups.

Hatched larvae (n=200) from each female that successfully ovulates will be maintained for 120 days according to the methods described for pallid sturgeon with or without vibration/noise based on their respective treatment groups. Survival will be assessed on a daily basis. Length and weight will be determined on a monthly basis. Proximate analysis will be conducted on a subsample of fish at the end of the 120-day period to assess overall fish condition. Survival, growth, condition factor, and proximate analysis will be compared within and between control and treatment groups by ANOVA.

Juvenile pallid sturgeon (n=30 per tank) will be exposed to vibration/noise that simulates the TRR at the intervals mimicing the proposed train schedule for a 120 days in triplicate. Control fish (n=30 fish per tank) will be maintained in a tank under identical conditions as the treatment fish except they will not be exposed to vibration/noise. Survival will be assessed on a daily basis. Length and weight will be determined on a monthly basis. Proximate analysis will be conducted on a subsample of fish at the end of the 120-day period to assess overall fish condition. Survival, growth, condition factor, and proximate analysis will be compared within and between control and treatment groups by ANOVA.

We are currently working on the optimization of immunological assays for pallid sturgeon to assess immune function. If these assays become available, immune function of pallid sturgeon juveniles could be determined at the completion of the 120-day period and compared between the treatment and control group.

The results of these experiments will determine the physiological effects of the TRR on the reproduction, development, growth, survival, and, potentially, the immune function of sturgeon. If a stress response occurs in the shovelnose sturgeon adults, it is safe to assume that the stress response would also be elicited in pallid sturgeon adults.

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***Estimated Budget**

Objective	Year	In-Kind Cost	Cost
1 – Noise/Vibration	1	$10-30K**	$10K-100K**
2 – Stress Response	1	$64.5K	$50K (itemized below)
3 – Physiological Effects	2	$66.5K	$50K (itemized below)

*Budget is not final and depends on a number of cost and technology factors not available at short notice but is otherwise as good as can provided at this time.

Detailed Budget for Objective 1 (Year 1):

Not yet determined.

** Estimating the appropriate noise/vibration parameters and technology has not been investigated as part of this preliminary proposal. This cost estimate gives a very rough idea of the possible range depending on if the information exists and can be readily simulated or whether expertise and technology needs to be acquired or developed to simulate physiologically relevant noise/vibration equivalent to proposed project.

Detailed Budget for Objective 2 (Year 1):

$20,741.00	PhD student Salary with Benefits for 12 months
$720.00	Radio-immuno assay analysis ($10/sample x 72 samples)
$3,960.00	Blood-plasma analysis ($5/sample x 72 samples x 11 parameters)
$5,000.00	Fish culture, care and feeding
$2,000.00	Personnel and travel to acquire fish
$12,000.00	½ of 20% Facilities operations
$7,551.57	17% US Fish and Wildlife Service Administrative Overhead
$51,972.57	**TOTAL outside funding for Objective 2 (Year 1)**
$24,000.00	20% of GS-13 Senior Researcher Salary plus beneifits
$17,000.00	20% of GS-11 Fish Culturist Salary plus benefits
$8,500.00	10% of GS-11 Fish Ecologist Salary plus benefits
$12,000.00	½ of 20% Facilities operations
$3,000.00	Laboratory supplies and chemicals
$64,500.00	**TOTAL In-Kind Agency Contribution**
$116,472.57	**TOTAL PROJECT COST FOR OBJECTIVE 2 (YEAR 1)**

Detailed Budget for Objective 3 (Year 2):

$20,741.00	PhD student Salary with Benefits for 12 months
$5,000.00	Fish culture, care and feeding
$3,000.00	Immunological supplies and equipment/experimental design
$2,000.00	Personnel and travel costs to acquire fish
$12,000.00	½ of 20% Facilities operations
$7,265,97	17% US Fish and Wildlife Service Administrative Overhead
$50,006.97	**TOTAL outside funding for Objective 3 (Year 2)**
$24,000.00	20% of GS-13 Senior Researcher Salary plus beneifits
$17,000.00	20% of GS-11 Fish Culturist Salary plus benefits
$8,500.00	10% of GS-11 Fish Ecologist Salary plus benefits
$12,000.00	½ of 20% Facilities operations
$5,000.00	Equipment and on-site supplies
$66,500.00	**TOTAL In-Kind Agency Contribution**
$116,506.97	**TOTAL PROJECT COST FOR OBJECTIVE 2 (YEAR 1)**